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DATA LINK VALIDATION PROGRAM.(U)

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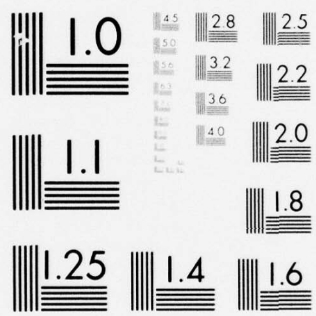

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Research and Development Technical Report

ECOM -4500

DATA LINK VALIDATION PROGRAM

Donald J. Blue
Robert G. Witham
Steven A. Bleier

Combat Surveillance & Target Acquisition Laboratory

May 1977

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The primary purpose of this investigation was to determine the effects of delivery system emplacement inaccuracies and relay antenna height on radio frequency (RF) sensor data link performance. The results indicate that, for this type of data transmission system, the effects of emplacement errors from a selected or optimum point (OP) was dependent on whether radio line-of-sight exists between the selected or "optimum" sites. If RF line-of-sight was at least partially available, increasing the antenna height to 30 feet normally resulted in a reliable link. Throughout these tests, reliable sensor data links over

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were established in hilly terrain wherever firm RF line-of-sight conditions existed. The tests demonstrated that reliable sensor-to-monitor links operated in hilly terrain can be established for distances up to 21 Km, and that reliable sensor-to-monitor links using multiple relays can be established for distances up to 76 Km. When operating in flat terrain, the tests demonstrated that the sensor-to-monitor data links performed reliably, even if RF line-of-sight did not exist for distances up to 29 Km. When the standard sensor antenna is used as opposed to the low loss antenna, the reliability of the link is degraded significantly except for distances of about 9.5 to 16.4 Km. For distances up to 47 Km, reliable multihop sensor data links were demonstrated. To summarize, the key to a reliable sensor data link is to provide RF line-of-sight links. Analysis provided by such organizations as the Electromagnetic Compatibility Analysis Center (ECAC) can provide data link analysis to insure that this condition exists.

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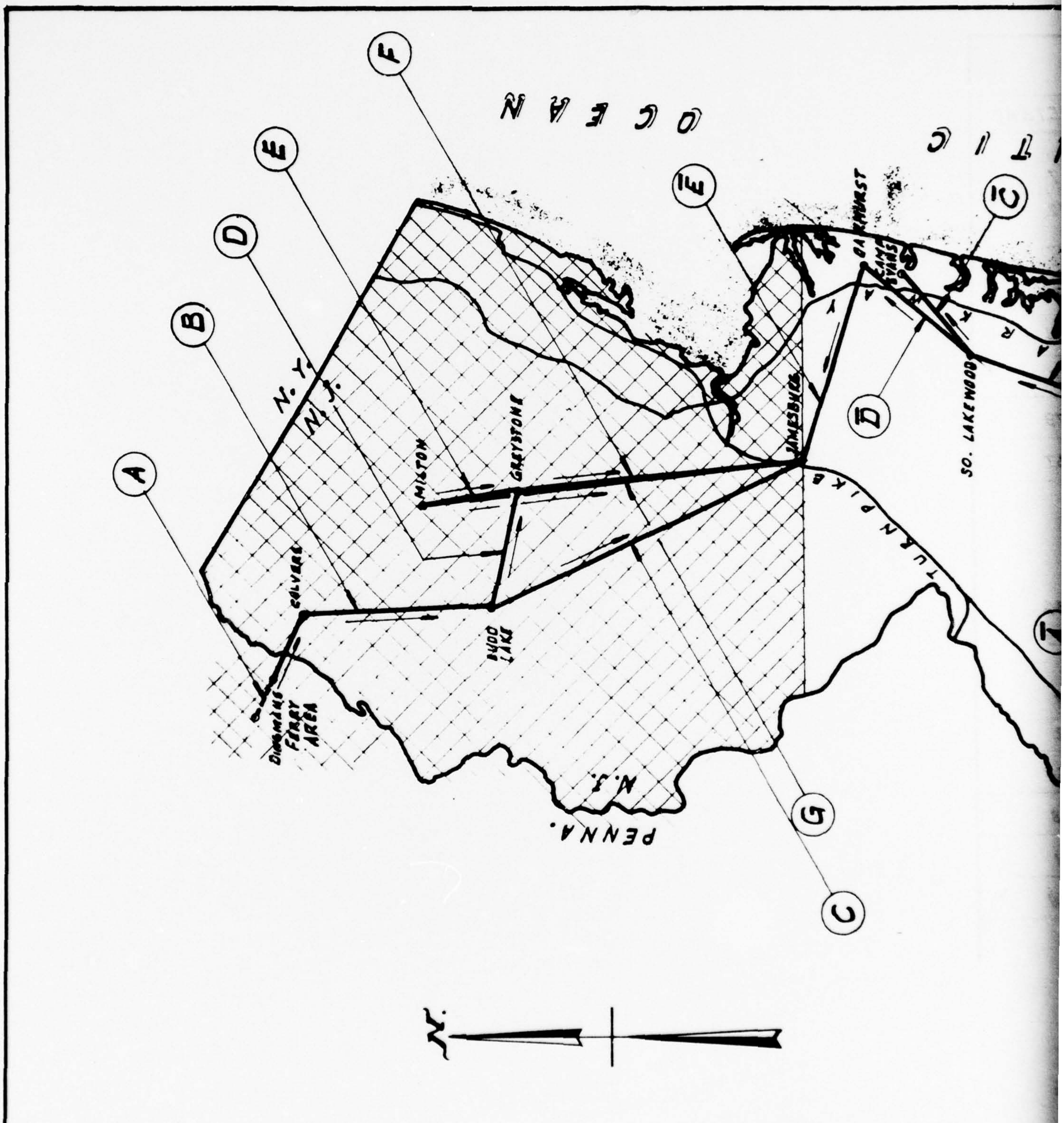
A
B
C
D
E
F
G
N.Y.
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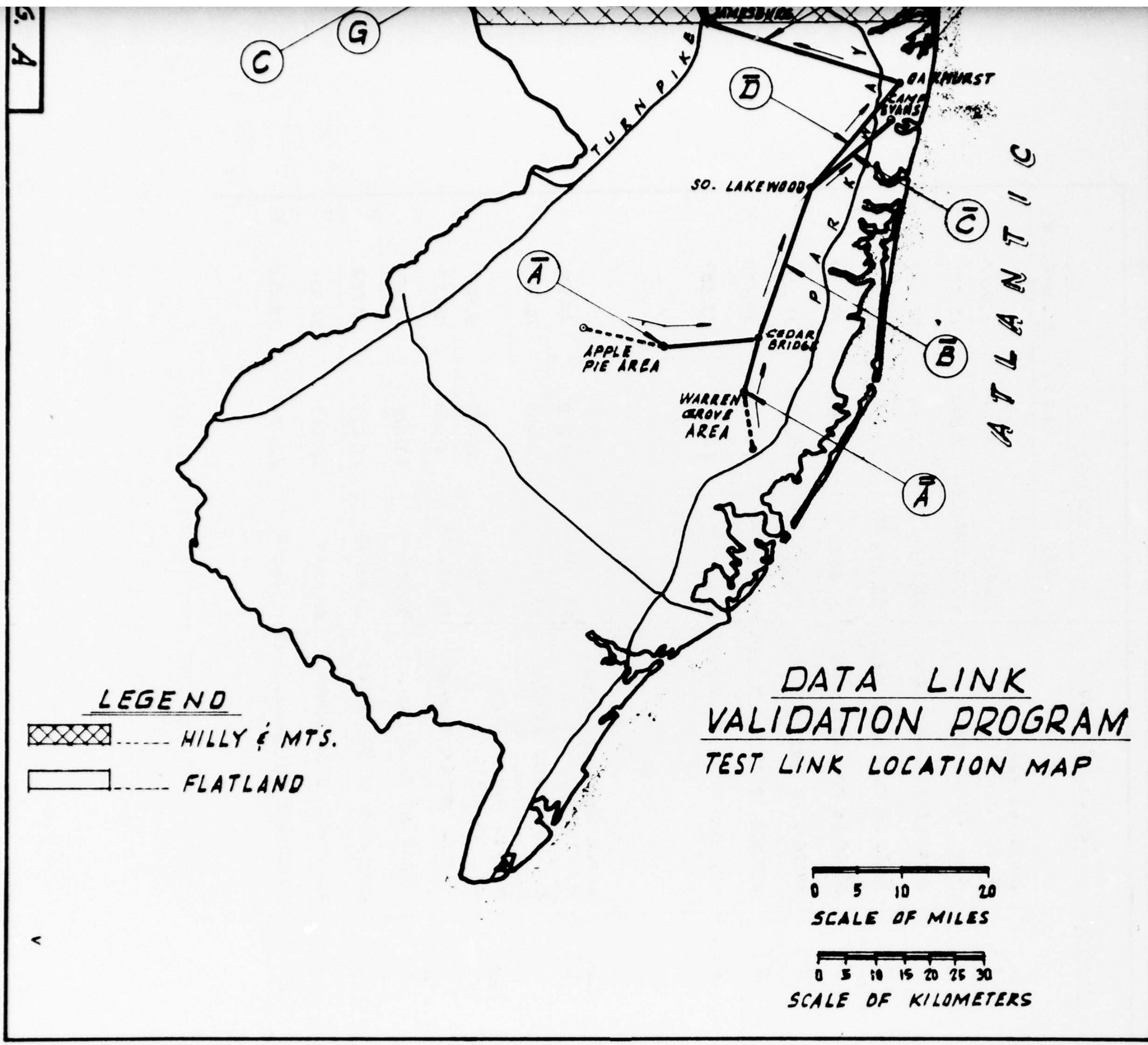
OCEAN
TIC
MILTON
GREYSTONE
JAMESBURG
OAKHURST
CAMP EVANS
SO. LAKEWOOD
TURNPIKE
BUDD LAKE
DINGMANS FERRY AREA
N.J.
PENNA.
N

FIG. A



DATA LINK VALIDATION PROGRAM

TEST LINK LOCATION MAP

LINK	DESCRIPTION	RANGE			
		FEET	MILES	KILOMETERS	
A	DINGMAN'S FERRY AREA K.5 TO K7	26400	5.000	8.047	NORTH
	K.5 TO CULVERS	41,246.^{23}	7.812	12.572	
B	CULVERS TO BUDD LAKE	106,713	20.211	32.527	
C	BUDD LK. TO J'BURG."FIELD"	223,478.^{85}	42.326	68.117	
D	BUDD LK. TO GREYSTONE	67,662.^{08}	12.815	20.624	
E	MILTON TO GREYSTONE	56,482.^{54}	10.697	17.215	
F	G'STONE. TO J'BURG. "FIELD"	192,515.^{88}	36.461	58.679	
G	MILTON TO J'BURG. "FIELD"	248,971.^{53}	47.154	75.887	
$\bar{A}$	APPLE PIE HILL AREA K1 TO K15	49,170	9.312	14.986	
	K1 TO CEDAR BRIDGE	55,194.^{52}	10.453	16.823	
$\bar{\bar{A}}$	WARREN GROVE AREA K1 TO K9	32,700	6.193	9.967	SOUTH
	K1 TO CEDAR BRIDGE	33,304.^{84}	6.308	10.152	
$\bar{B}$	CEDAR BR. TO SO. LKWD.	93,021.^{20}	17.618	28.354	
$\bar{C}$	SO. LKWD. TO CAMP EVANS	61,441.^{65}	11.637	18.728	
$\bar{D}$	SO. LKWD. TO OAKHURST	80,483.^{50}	15.243	24.531	
$\bar{E}$	OAKHURST TO J'BURG. "TWR."	116,340.^{78}	22.034	35.460	

FIG. B

FIG B: TEST LINK DESCRIPTION AND RANGE

INTRODUCTION

Background: Questions have been raised regarding the reliability of sensor data link systems deployed by the various tactical emplacement methods (i.e., hand, ballistic, and airdrop). The uncertainties are due mainly to the emplacement inaccuracies, antenna heights, and terrain factors. As a result Project Manager (PM), Remotely Monitored Battlefield Sensor System (REMBASS) tasked the Data Transmission, Processing and Display Technical Area, Combat Surveillance and Target Acquisition Laboratory (CS & TA Lab), Fort Monmouth, New Jersey, to conduct a limited investigation of the reliability of sensor RF data links deployed in hilly and flat terrain under realistic field conditions.

Program Objective: The objective of the program was to gather sufficient information through field tests and investigative studies in order to determine the reliability of sensor RF data links when deployed in various terrains.

Scope: The program was conducted in two phases, as follows:

a. Phase A - A literature search was initiated at the beginning of the program. The search attempted to locate and review those reports which emphasized the following:

(1) The operation of low power VHF data links utilizing relatively low antenna heights in various types of terrain.

(2) An analysis of the various performance models which were based on comprehensive terrain profile and measurement studies.

(3) An evaluation of data previously gathered during field exercises which utilized sensor data links.

b. Phase B - A series of field tests were conducted in Eastern Pennsylvania and New Jersey during October and November of 1976. These tests examined those areas of sensor data operation not previously investigated. Specifically, the effects on system operation of both relay emplacement errors and various relay antenna heights. Several test configurations were utilized; e.g., sensor-to-monitor, sensor through relay-to-monitor, etc. Information obtained from both phases are included in this report.

FIELD TESTS

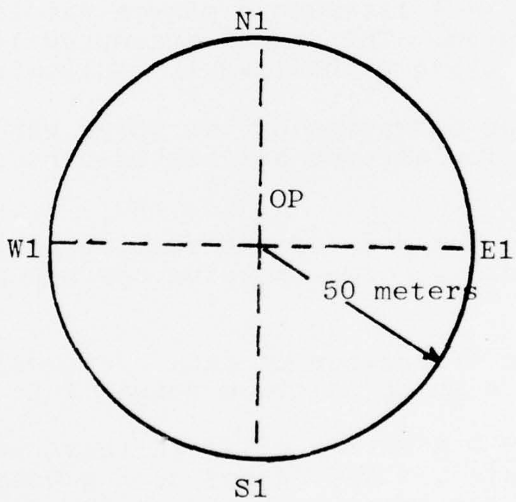
Field Test Objectives: A list of preliminary objectives for Phase B (Field Test) were determined by reviewing the Phase A data. The preliminary objectives were then reviewed with representatives from PM-REMBASS, the U.S. Army Intelligence

Center and School (USAICS), and the Army Materiel System Analysis Agency (AMSAA). The approved objectives of the field test are as follows:

(1) To demonstrate that a sensor-to-monitor (AN/USQ-46) link can be implemented over a nominal distance of 9.5 miles (15 Km) in both hilly and flat, vegetated terrains.

(2) To demonstrate that a multihop sensor data link can be implemented to cover a distance greater than 31 miles (50 Km) in both hilly and flat, vegetated terrain.

(3) To simulate the effects on the data link's performance associated with emplacement errors. This was accomplished by placing an expendable relay (EXRAY) at five locations for each test configuration. The five locations included an optimum point (OP) representing the desired relay site, and four relay offset points (N1, E1, S1, W1) representing the maximum allowable deployment error. Each offset point was located 150 feet (50 meters) from the OP. (See diagram below):



(4) To simulate operational and proposed sensor data link models using various antenna heights. For each relay location mentioned in (3), tests were conducted with the EXRAY(s) spike antenna height adjusted from 10 to 30 feet.

Field Test Instrumentation: Field Test instrumentation consisted of the following items:

a. MA-56 Hang-Up EXRAY Relay: Three expendable (EXRAY) relay assemblies were constructed with components obtained from CS&TA Laboratory and Tobyhanna Army Depot. The

base mounts and spike antenna support assemblies were fabricated by Evans Area Sheet Metal Shop of the ECOM Research and Development Test Support Activity (RDTSA). One EXRAY assembly included provisions for interfacing a Valid Message Counter (VMC) unit. All EXRAY modules were standard Phase III types (See Figure 1). Sensitivity of the receivers was measured to be -120 dbm. Transmitter power output ranged between 2.4 and 3.5 watts.

b. AN/USQ-46 VMC Radio Monitor System: An AN/USQ-46 Radio Monitor System (hereafter referred to as the monitor system) was utilized as the test terminal and data recording device. The Receiver sensitivity was measured on all AN/USQ-46 between -118 and -121 dbm. In addition to the AN/USQ-46, the monitor system included a VMC and a Sensor Inband Radio Relay (SIRR) omni-directional antenna manufactured by Phelps-Dodge Communications Company, Marlboro, NJ.

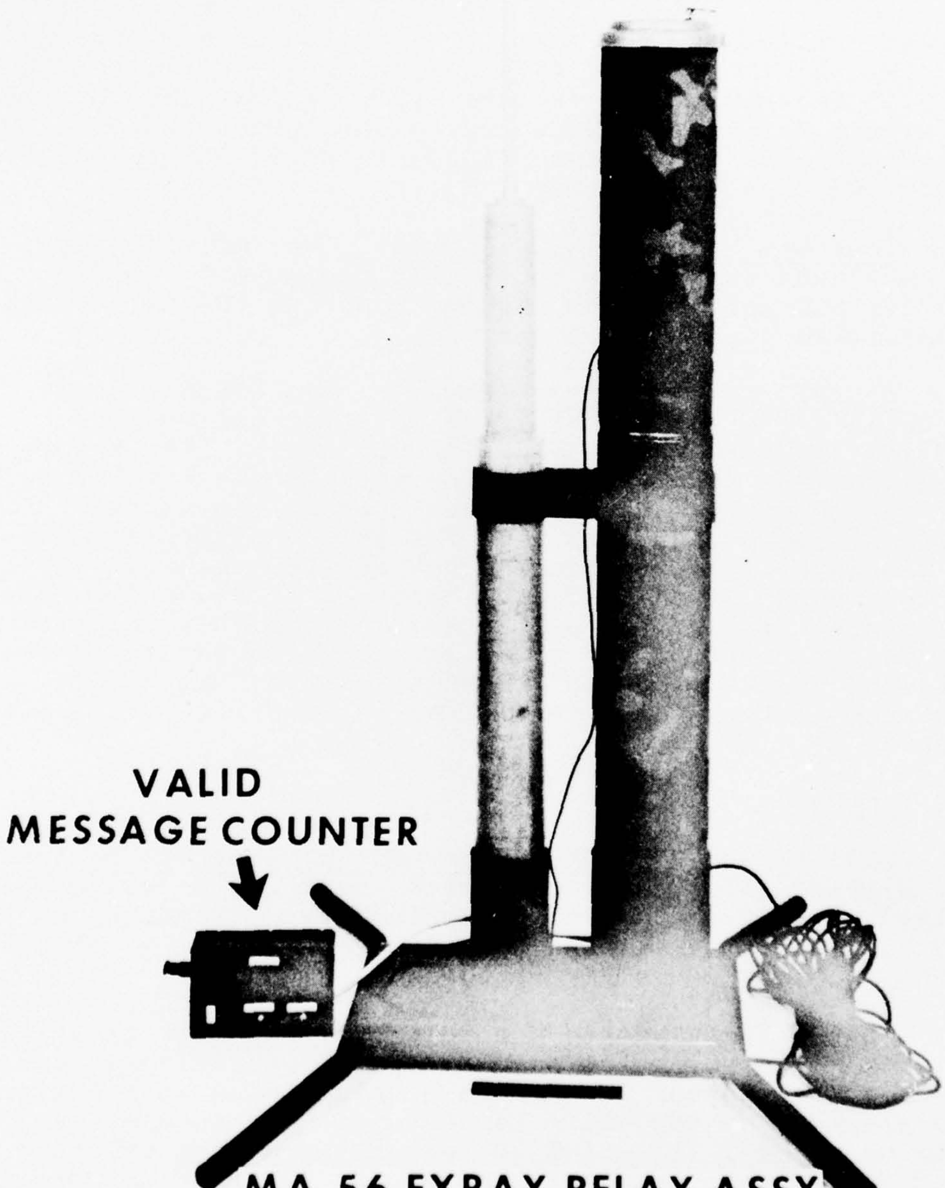
c. Test Set Radio TS-2963/USQ-46: Two Emmission Generators were used during the tests as a replacement for the Keyer in certain applications and for checking the performance of the AN/USQ-46 Monitor Receiver.

d. MINISID Keyer/Counter (Keyer): Two MINISID Keyer/Counter units (referred to hereafter as Keyer units) were designed and fabricated by the CS&TA Laboratory. The Keyers contained a Common Module Transmitter with output power ranging from 2.4 to 3.5 watts. The Keyer was used as the signal initiating device during each test run unless otherwise indicated. The Keyer's light emitting device (LED) counter unit registered a count of one for each burst of 10 Phase III type sensor messages transmitted by the Keyer's common module transmitter. The transmitter was in no way modified for these tests. The unit was designed for MINISID Whip Antenna, but other antennas such as the SIRR antenna, can be used with RF adapters. (See Figures 3, 4 and 7).

e. Antennas:

(1) AN/GRQ-21 EXRAY Spike Omni-Directional Antenna System: A spike antenna was used with the EXRAY's during the test. This antenna was useful in implementing the required 10-foot and 30-foot relay antenna heights because of its collapsible construction. (See Figure 5).

(2) SIRR Broadband Monopole Omni-directional Antenna: This antenna was used as the monitor system receiving antenna. It is part of the Sensor Inband Radio Relay (SIRR) currently under development by the CS&TA Laboratory. The antenna was installed on a Model 5111-LI-T 30-foot antenna mast assembly when used at the monitor site. The Model 5111-LI-T antenna kit also included a Yagi antenna that was utilized during a hilly terrain, long range test. The SIRR antenna was also used with the Keyer during extended range sensor-to-monitor tests (See Figure 6).



MA 56 EXRAY RELAY ASSY
& AN/GRQ-21 SPIKE ANTENNA

Figure 1

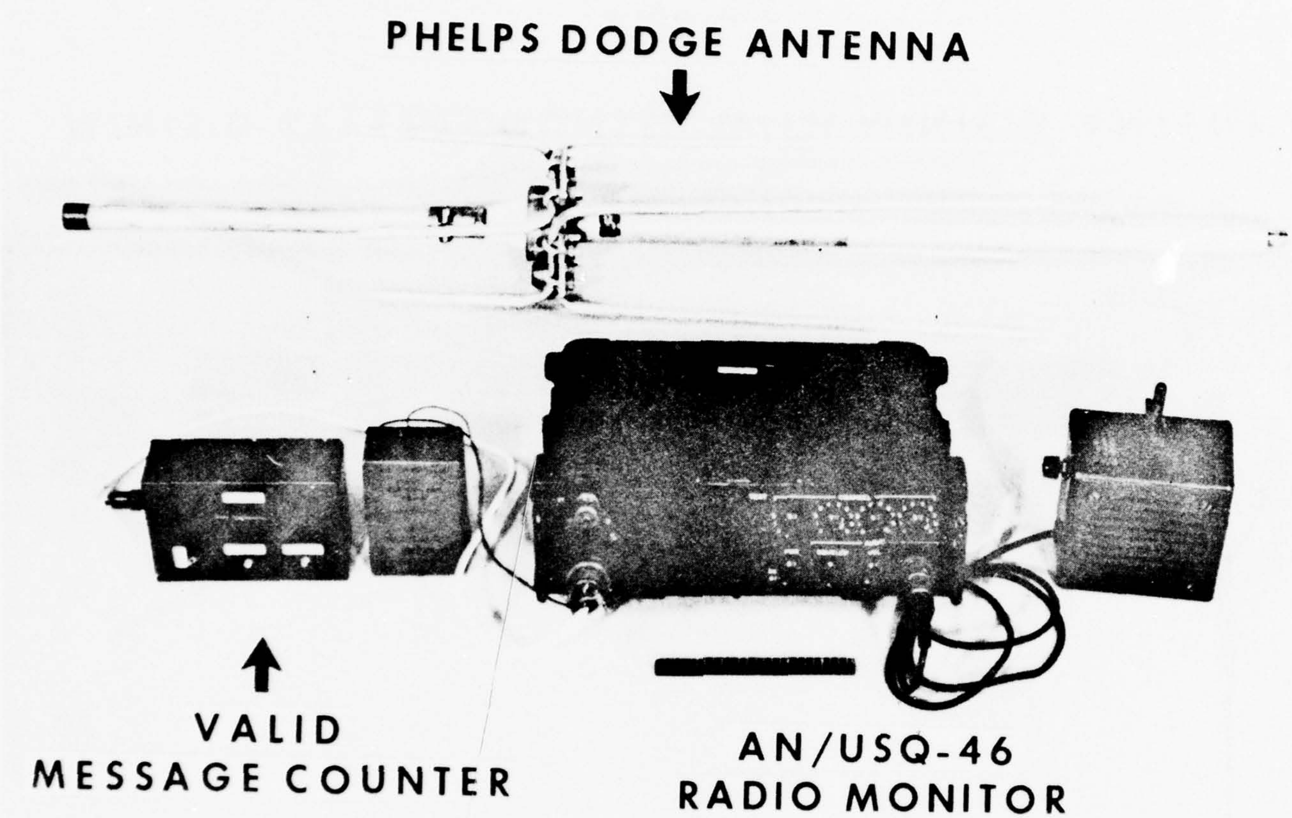
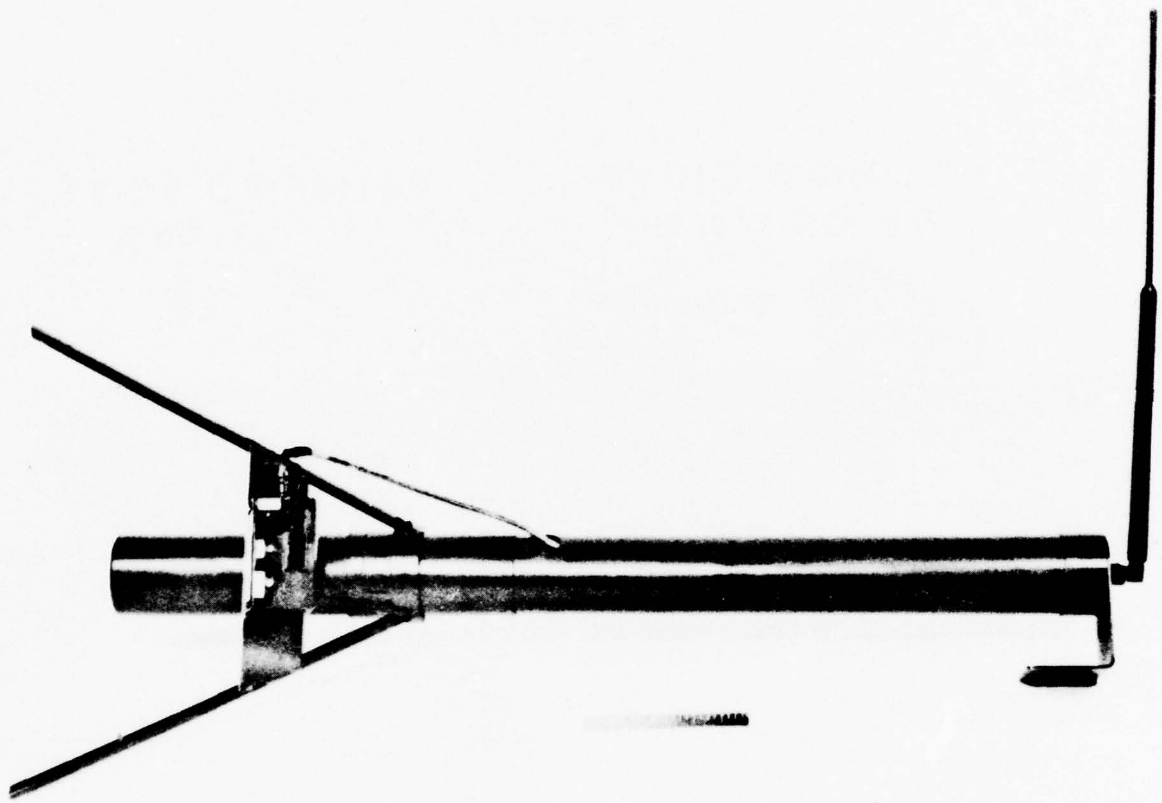
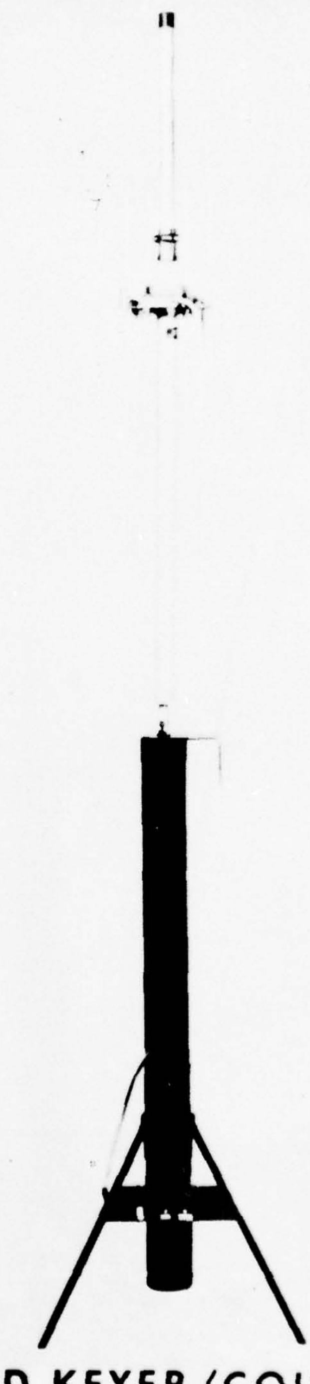

PHELPS DODGE ANTENNA
VALID
MESSAGE COUNTER
AN/USQ-46
RADIO MONITOR

Figure 2



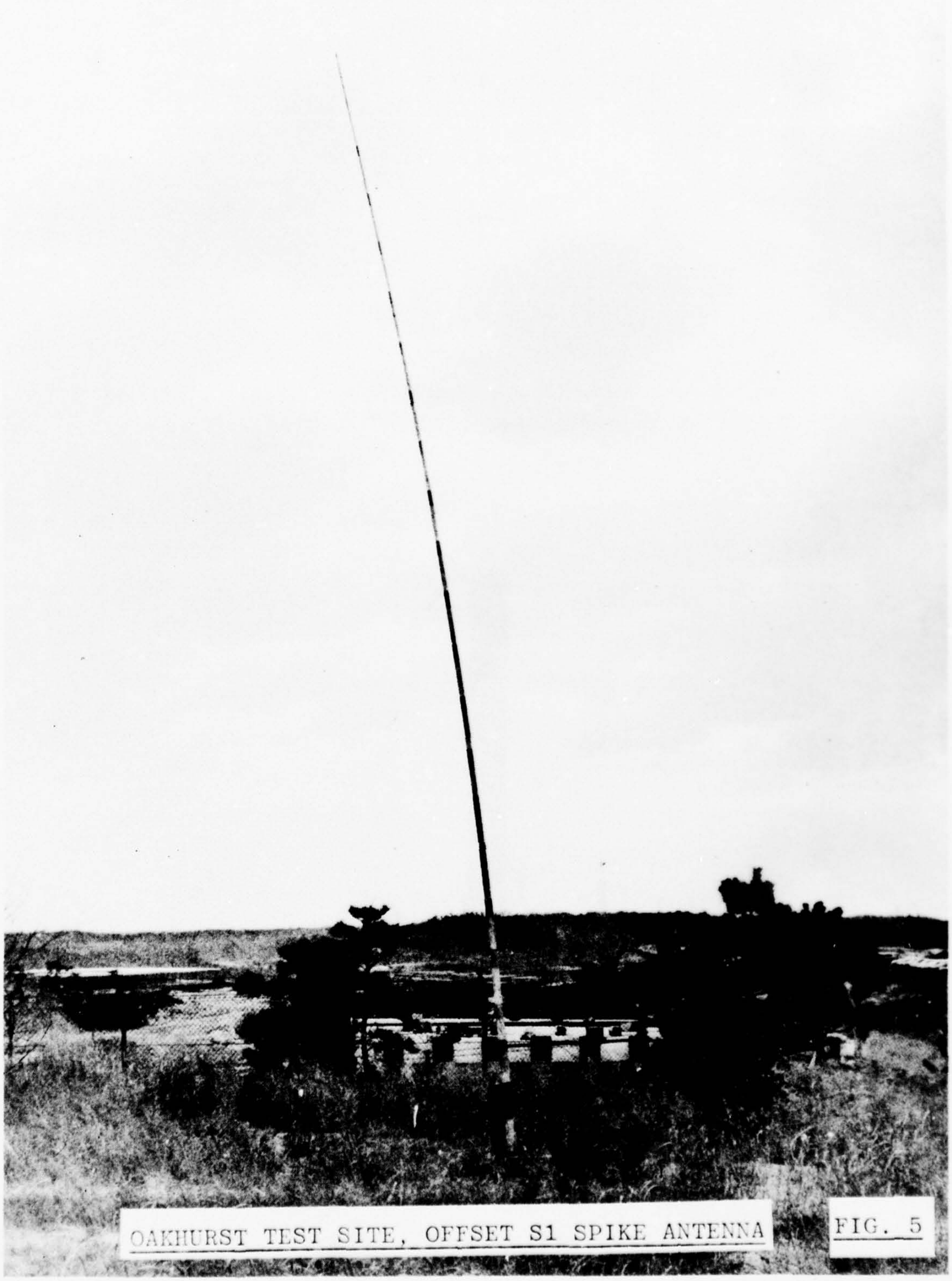
MINISID KEYER/COUNTER WITH MINISID ANTENNA

Figure 3



MINISID KEYER/COUNTER
WITH PHELPS DODGE ANTENNA

Figure 4



OAKHURST TEST SITE, OFFSET S1 SPIKE ANTENNA FIG. 5

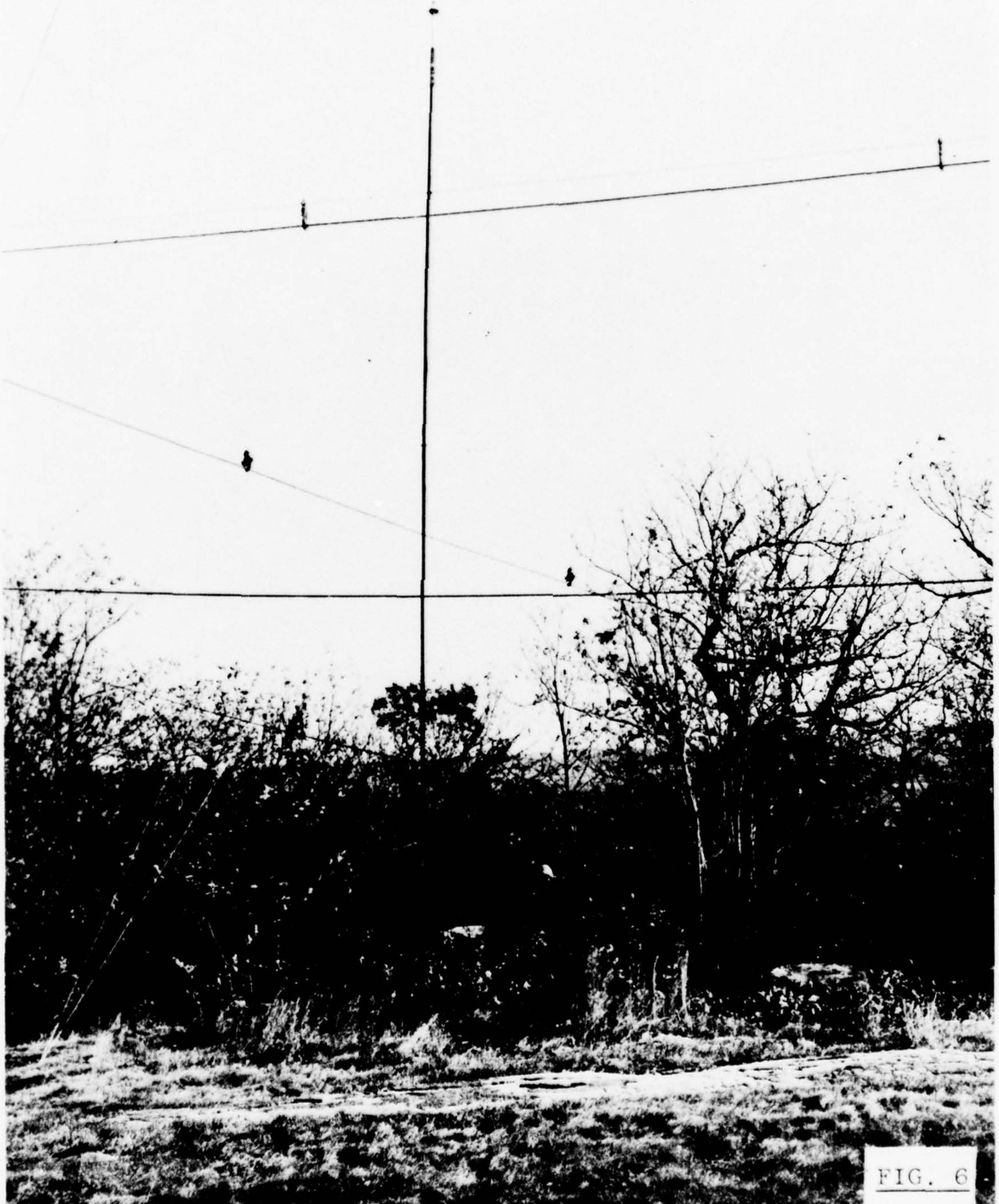


FIG. 6

MONITOR SITE AT CULVERS "OP" - SIRR ANTENNA ON 30 FOOT MAST

"TOSS-UP" APPLE PIE TEST SITE K6 FIG. 7

(3) "Toss-up" Antenna: The "Toss-up" Antenna is part of the Navy's Forward Pass System and is currently used by the U.S. Marine Corps SCAMP Platoons with the AN/GRQ-21 Back-pack EXRAY. A Toss-up Antenna was used during the sensor-to-monitor tests in the flat terrain area (see Figure 7).

f. Valid Message Counter (VMC): Two VMC units were designed and fabricated by the CS&TA Laboratory. The two VMC's were used to count and display (via LED readout) the number of valid messages received by both the monitor system and the preceeding EXRAY. The data which determined link performance for all tests was obtained using the VMC (see Figs. 1 and 2).

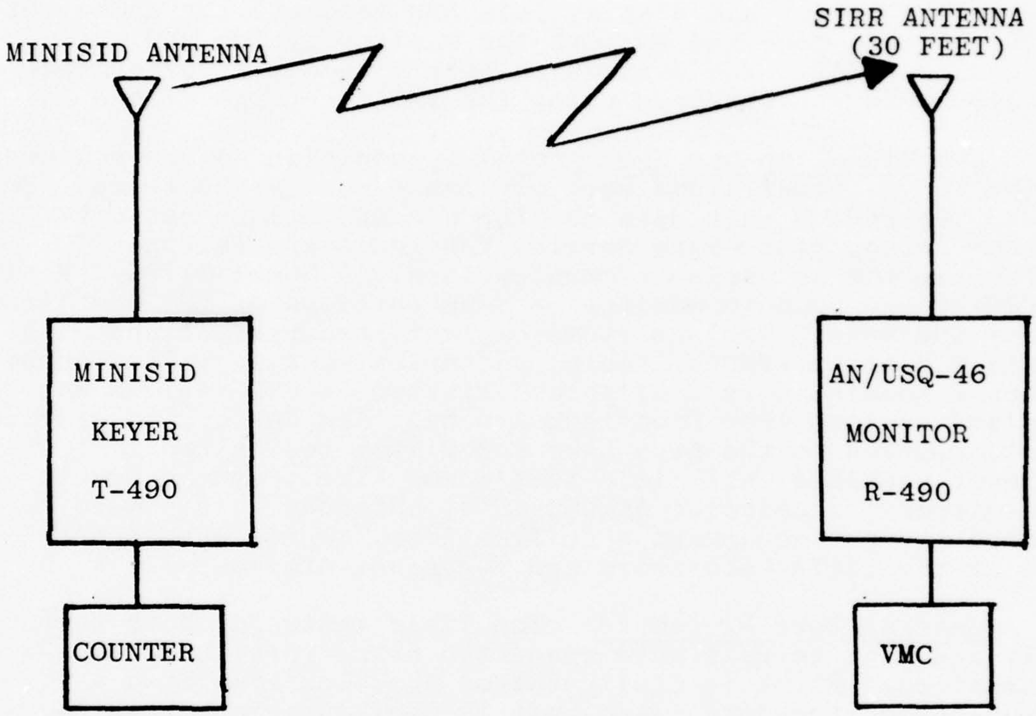
g. Miscellaneous Equipment: In addition to the equipment listed above, other items were available during the tests. Four PRC-25 VHF radios were used for the communications network. The New Jersey State Fire Service VHF radio and telephone systems served as backup communications. A Model 91785-1 Mini-AN/USQ-46 was used to monitor various portions of the test links during the runs. Various items of Test, Measurement and Diagnostic Equipment (TMDE), tools, batteries, and a limited number of spare modules were available. Finally, a 4WD Vehicle was obtained on loan from Picatinny Arsenal, New Jersey, to provide transportation to the Budd Lake and Milton test sites. Wherever possible, all field test items (i.e., common module transmitters, receivers, AN/USQ-46's, antennas, etc.) were checked against equipment specifications. These checks were made at the CS&TA Laboratory and Tobyhanna Army Depot.

General Test Procedure: The field tests for both the hilly and flat terrain were conducted using three basic configurations. First is Configuration A, which simulated a sensor-to-monitor data link; next is Configuration B, which simulated a sensor-to-relay-to-monitor data link, and finally, Configuration C, which simulated a sensor-to-monitor link using two relays. All configurations attempted to determine the effects of relay emplacement errors and antenna heights on overall link performance.

a. Sensor-to-Monitor Tests (Configuration A): These tests were conducted with the Keyer located at the Dingman's Ferry (hilly terrain), and at both Apple Pie and Warren Grove (flat terrain) sensor sites. The AN/USQ-46 monitor system was located at Culvers site for the hilly terrain tests and at Cedar Bridge site for the flat terrain tests. For each test, a predetermined number of Keyer transmissions were initiated from a sensor site. The number of messages received at the monitor was compared to the number of messages sent from the Keyer site, thus providing the necessary link reliability data. This procedure was repeated at each Keyer site.

In the test configuration shown below, the transmitter Phase III channel is denoted by T and the receiver Phase III channel is denoted by R. The link reliability was calculated as follows:

$$\text{Link Reliability} = \frac{\text{Total Number of Received Messages}}{\text{Total Number of Keyer Transmissions}}$$

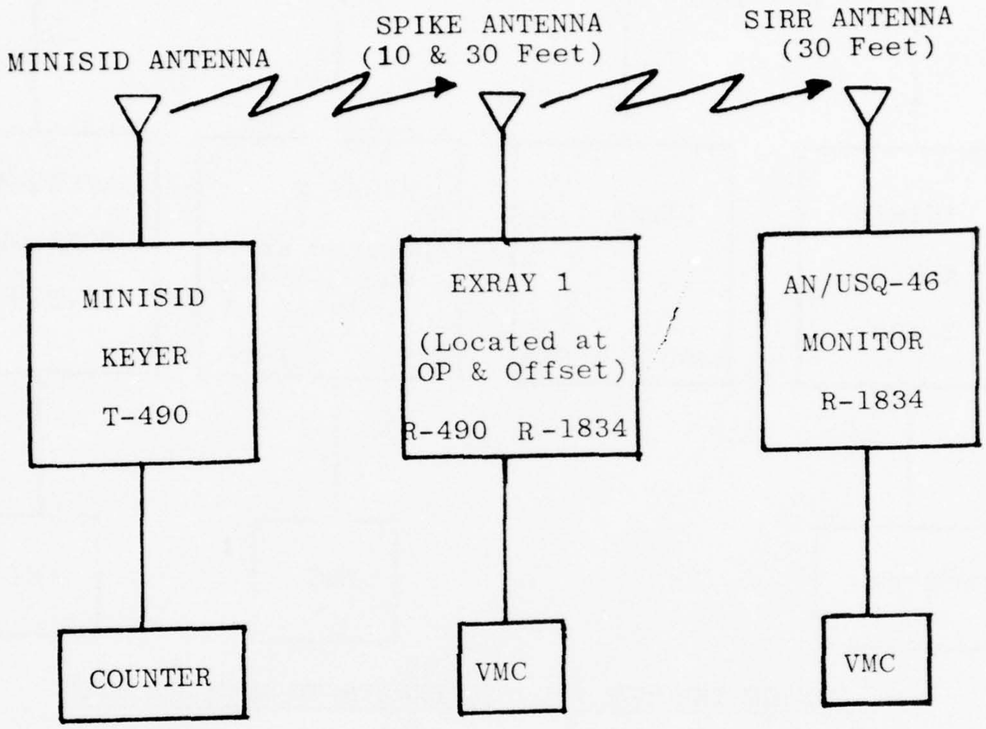


SENSOR-TO-MONITOR TEST

CONFIGURATION (A)

b. Sensor-Relay-Monitor Tests (Configuration B): These tests were conducted with the Keyer located in the Dingman's Ferry Area for hilly terrain tests and in the Warren Grove Area for the flat terrain tests. The monitor system was then positioned at the Budd Lake (hilly terrain) test site and at the Lakewood (flat terrain) test site. An EXRAY/VMC relay was located at the Culvers (hilly terrain) and Cedar Bridge (flat terrain) test sites. Again, the Keyer transmitted a predetermined number of messages. The relay was located at the test site's OP with antenna heights of 10 and 30 feet. The link's reliability was determined as described in the previous paragraph. This procedure was repeated for each of the four relay offset points for a minimum total of 10 tests each for the hilly and

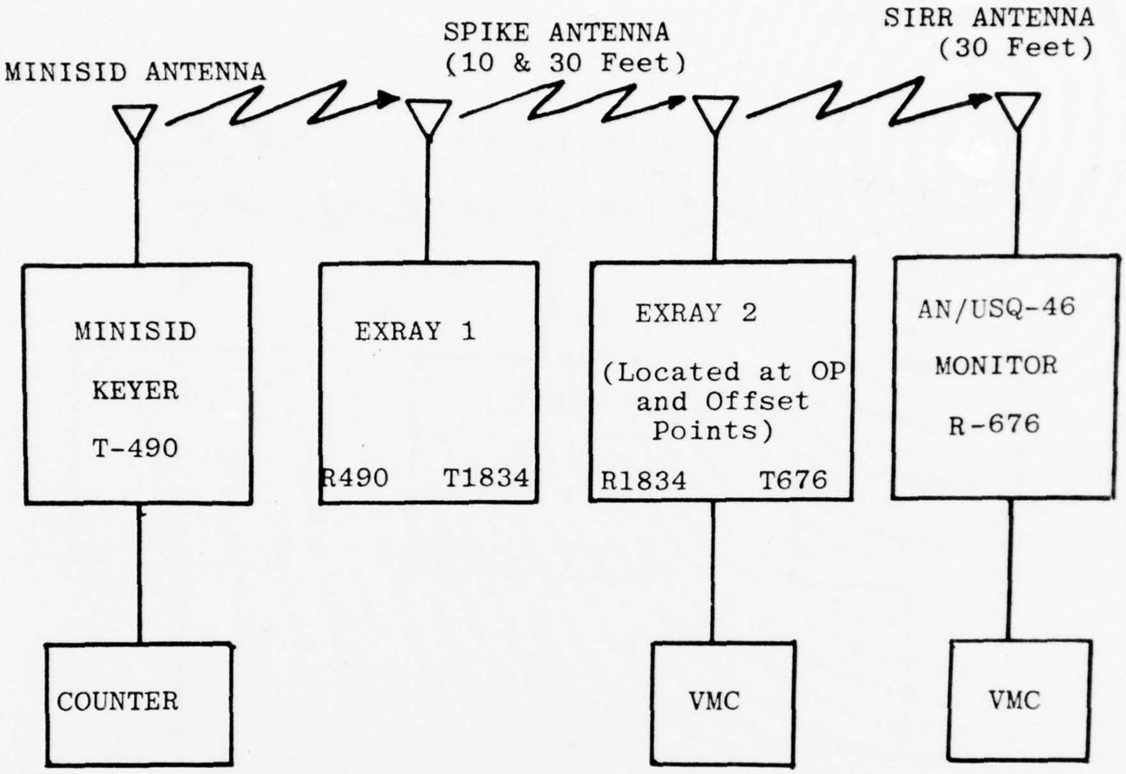
flat terrain areas.



SENSOR THROUGH EXRAY-TO-MONITOR SET

CONFIGURATION (B)

c. Sensor Through Multiple Relays-to-Monitor Tests (Configuration C): For these tests, the links outlined in Configuration B were expanded by the addition of another EXRAY relay. Equipment malfunctions prevented expanding to three relays. The monitor system was located at the Jamesburg test site for both hilly and flat terrain tests. The relay immediately preceeding the monitoring system was located at the site's OP and four offset points. All other link components were positioned, in most cases, at their respective site's OP(s). Tests were conducted with the preceeding relay antenna height adjusted to both 10 feet and 30 feet for a minimum total of 10 tests for each basic configuration. (NOTE: It would have been desirable to see the effects of moving all the relays to their respective site offsets and using various combinations of antennas and antenna heights. However, due to resource and time limitations, this could not be accomplished.) All other relay antennas were adjusted to the same height. Link reliabilities were calculated as before.



SENSOR THROUGH TWO (2) EXRAYS-TO-MONITOR TEST

CONFIGURATION (C)

Hilly Terrain Tests:

a. Hilly Terrain Relay Site and Sensor (Keyer) Site Descriptions:

(1) Sensor Site Description: The hilly terrain sensor (Keyer) sites were located in the Dingman's Ferry area of Pennsylvania, north of the Delaware Water Gap between Layton, New Jersey and Edgemere, Pennsylvania. The seven Keyer sites ranged in distance from 9 to 14 miles (14.5 - 22.5 Km) from the Culvers monitor site. Keyer site diagram and photographs are in Appendices A1 and A2.

(2) Relay Site Descriptions: The relay test sites are situated in the vicinity of selected New Jersey State Department of Environmental Protection, Division of Parks and Forests Fire Lookout Towers. The numbers in parentheses following the site names are the site elevations above sea level.

(a) Culvers Fire Tower Test Site (1503 ft/458^{M}): Culvers has the highest elevation of any of the test sites. It is situated on the Appalachian Trail on Kittatinny Ridge, south

of High Point, New Jersey. Culvers served as a monitor and relay site during the hilly terrain tests. Site diagram and photographs of the Culvers Test Site are in Appendices A3-A6.

(b) Budd Lake Fire Tower Test Site (1206 ft/368M): The Budd Lake site is located 1.25 miles (2 Km) north of Budd Lake, New Jersey. The test area is situated on a sloping, heavily foliated hill near the fire tower. The site served as a monitor and relay point during the tests. Site diagram and photographs are in Appendices A7-A10.

(c) Milton Fire Tower Test Site (1386 ft/422M): The Milton site is located on Bowling Green Mountain, west of Green Pond and Longwood Valley, New Jersey. The test area is located on a heavily foliated ridge. The offset points are situated in dense woods near the fire tower. The New Jersey Forest Fire Service operates a VHF (151-159 MHz) 300 watt repeater from the tower. Milton served as a Keyer and relay point during the tests. Site diagrams and photographs are in Appendices A11-A14.

(d) Greystone Fire Tower Test Site (1033 ft/315M): The Greystone site is located on Union Hill 1.5 miles (2.4 Km) north of Greystone State Hospital. The transmitter/antenna from a commercial FM station is located near/on the tower. Greystone served as a Keyer and relay point during the tests. Site diagrams and photographs are in Appendices A15-A16.

(e) Jamesburg Test Site (160 ft/49M): The Jamesburg Test Site is located in Thompson Park, Jamesburg, New Jersey. It is south of Lake Manalapan and two miles (3.2 Km) north of the Middlesex-Monmouth County lines. Jamesburg served as a monitor site during long range multihop tests for the hilly and flat terrain tests. Plot diagrams and photographs are in Appendices A17-A19.

b. Sensor-to-Monitor Tests (Configuration A):

(1) Location: These tests were conducted with the Keyer located at the Dingman's Ferry sensor sites. The seven Keyer points were located at intervals of approximately 2 miles (3.2 Km) from each other. The monitor with a 30 foot antenna was located at the Culvers optimum point (OP). The Electromagnetic Compatibility Analysis Center (ECAC) provided a degree of RF shielding chart showing RF line-of-sight for 10 and 30 ft antennas at Culvers Test Site. This chart showed that RF line-of-sight exists to all Keyer sites. This chart is not included but is available upon request.

(2) Results: The test results are shown in Table 1. Since RF line-of-sight existed between the Keyer and AN/USQ-46, the results were excellent, showing high link reliability out to 13 miles (20.9 Km).

Run	Dingman's Ferry Keyer/Count	Range Distance	Culvers AN/USQ-46/Count	Link Reliability
1	K1/1000	9 mi (14.5 Km)	OP/998	99.8%
2	K2/1000	9.5 mi (15.3 Km)	OP/994	99.4%
3	K3/1000	10 mi (16.1 Km)	OP/992	99.2%
4	K4/1000	10.5 mi (16.9 Km)	OP/962	96.2%
5	K5/1000	11 mi (17.7 Km)	OP/915	91.5%
6	K6/200	12 mi (19.3 Km)	OP/200	100.0%
7	K7/200	13 mi (20.9 Km)	OP/213[1]	100.0%

TABLE 1: DINGMAN'S FERRY TO CULVERS SENSOR-TO-MONITOR TEST RESULTS

Note 1: Extra counts due to interference from local fire radio dispatcher.

c. <u>Sensor-to-Relay-to-Monitor Test (Configuration B)</u>:

(1) <u>Location</u>: These tests were conducted with the Keyer located on a ridge .5 miles (.8 Km) east of K1. EXRAY 1, with a VMC and spike antenna, were positioned in turn at Culvers OP and at each offset point. The AN/USQ-46 with VMC and 30 foot mast and a SIRR omni-directional antenna were located at the Budd Lake optimum point (OP). The 4/3 Earth terrain profiles representing the RF propagation path for the EXRAY to monitor link showed that RF line-of-sight existed between Culvers and Budd Lake optimum point. The ECAC data is in Appendix C-1.

(2) <u>Results</u>: The test results are shown in Table 2, for a 10-foot relay antenna height and Table 3, for a 30-foot antenna height. Column A represents the reliability of the Keyer to EXRAY 1 link (7.8 miles/12.6 Km). Column B represents the reliability of EXRAY 1 to monitor link (20.2 miles/32.5 Km). Column C represents the overall link reliability for the Keyer-to-monitor-link (28 miles/45.1 Km).

Again, the results were excellent. However, in Table 2, with the EXRAY located at E1, a link could not be established. By raising the EXRAY antenna to 14 feet, approximately 88% of the Keyer data was received by the EXRAY. In Table 3, with EXRAY 1 antenna raised to 30 feet, the results were 95%. Terrain masking was the probable cause of the problem.

d. <u>Sensor Through Two Relays to Monitor Test (Configuration C)</u>:

(1) <u>Location</u>: These tests were conducted with the Keyer again located at K.5. EXRAY 1 was located at Culvers offset point N1 and EXRAY 2 with VMC located at the Budd Lake's OP and at each offset point. The AN/USQ-46 Monitor was located at the Jamesburg site. At least two runs were conducted for each EXRAY 2 position with spike antenna heights of 10 feet and 30 feet, respectively. The 4/3 Earth terrain profiles representing the RF propagation path for the EXRAY to monitor link showed that RF line-of-sight was at best marginal between Budd Lake and Jamesburg optimum points. The ECAC data is in Appendices C1 and C2.

(2) <u>Results</u>: The test results are shown in Table 4 for the 10 foot EXRAY antenna height and Table 5 for the 30 foot EXRAY antenna height. Column A represents the reliability of the Keyer to EXRAY 1 to EXRAY 2 link (28 miles/45.1 Km). Column B represents the reliability of EXRAY 2 to monitor link which had marginal RF line-of-sight (42.3 miles/68.1 Km). Column C represents the overall link reliability (70.3 miles/113.2 Km). Initially, the antennas for EXRAY 1 and 2, located at Culvers and Budd Lake respectively, were 10 feet high but when data was taken, a reliable link was found not to exist. A reliable link could only be established when the antenna for EXRAY 1, located at the N1 site, was raised to 30 ft and the antenna for EXRAY 2 was raised to 23 feet. Previous tests

Run	Dingman's Ferry Keyer/Count	Culvers EXRAY I/ VMC/Count	Budd Lake AN/USQ-46 VMC/Count	Link Reliabilities		
				A	B	C
1	K.5/1000	OP/976	OP/943	98.5%	96.7%	95.2%
2	K.5/1000	W1/991	OP/991	99.1%	100.0%	99.1%
3	K.5/1000	S1/976	OP/968	97.6%	99.1%	97.6%
4	K.5/1000	E1/O	OP/0	0	0	0
5	K.5/1000	E1/879	OP/873	87.9%	99.3%	87.3%
6	K.5/990	N1/990	OP/990	100.0%	100.0%	100.0%

TABLE 2: Dingman's Ferry to Culvers to Budd Lake (One Relay) Test Results Using 10 Foot Spike Antenna

Run	Activation	Culvers EXRAY I/ Activations	Budd Lake AN/USQ-46/ Valid Msgs.	A	B	C
1	K.5/1000	OP/985	OP/943	98.5%	95.7%	94.3%
2	K.5/1000	W1/994	OP/983	99.4%	98.9%	98.3%
3	K.5/1000	E1/947	OP/947	94.7%	100.0%	94.7%
4	K.5/1000	N1/1000	OP/1000	100.0%	100.0%	100.0%
5	K.5/1000	S1/1000	OP/992	100.0%	99.2%	99.2%

TABLE 3: Dingman's Ferry to Culvers to Budd Lake (One Relay) Test Results using 30 Foot Spike Antenna

Run	Dingman's Ferry Keyer/Count	Budd Lake EXRAY 2	Jamesburg AN/USQ-46	Link Reliabilities		
				A	B	C
1	K.5/500	S1/340	OP/336	68.0%	98.8%	67.2%
2	K.5/500	E1/500	OP/O	100.0%	0%	0%
3	K.5/500	N.5/500	OP/O	100.0%	0%	0%
4	K.5/500	OP/496	OP/O	99.2%	0%	0%
5	K.5/500	W1/498	OP/O	99.6%	0%	0%

TABLE 4: *Dingman's Ferry to Culvers to Budd Lake to Jamesburg* (Two Relay) Test Results Using 10 Foot EXRAY Antenna Heights

Run	Dingman's Ferry Keyer/Count	Budd Lake EXRAY 2	Jamesburg AN/USQ-46/ VMC/Count	Link Reliabilities		
				A	B	C
1	K.5/1000	S1/999	OP/998	99.9%	99.89%	99.8%
2	K.5/500	E1/500	OP/500	100.0%	100.0 %	100.0%
3	K.5/500	N1/498	OP/O	99.6%	0%	0%
4	K.5/500	N.5/498	OP/402	99.6%	80.7 %	80.4%
5	K.5/500	OP/500	OP/O	100.0%	0%	0%
6	K.5/500	W1/499	OP/O	99.8%	0%	0%

TABLE 5: Dingman's Ferry to Culvers to Budd Lake (Two Relay) Test Results using 30 Foot EXRAY Antenna Heights

showed that N1 site at Culvers provided the most reliable link. It was further found that the Keyer battery was low. This was replaced between Runs 1 and 2. Though a reliable link was eventually established between the Keyer and Budd Lake sites, the link between EXRAY 2 at Budd Lake and the monitor at Jamesburg could not be established showing that a reliable link over long distances could not be expected when RF line-of-sight does not exist. Table 4 shows the results after raising the EXRAY antennas. Table 5 shows the results for both EXRAY 1 and 2 having antenna heights at 30 feet. For Run 3, a link between Budd Lake and Jamesburg could not be established. For Run 4, the EXRAY 2 antenna was moved one-half the distance between N1 and OP sites. For Runs 5 and 6, the 0% link between the OP (Optimum points) at Budd Lake and Jamesburg was due to masking by either the 65 foot fire tower or the terrain.

e. Supplemental Tests: In addition to the Configuration A through C tests, other tests were conducted in the hilly terrain area to augment the hilly terrain data. These tests were conducted in four configurations and are discussed below.

(1) Greystone to Jamesburg (Configuration A):

(a) Location: These tests were conducted with either a Keyer or the Test Set Radio TS-2963/USQ-46 and EXRAY 3 combination at Greystone. The monitor was located at Jamesburg and selectively tuned to either the Keyer or EXRAY 3 channel. The 4/3 Earth terrain profiles representing the RF propagation path for the Greystone to Jamesburg link showed that RF line-of-sight existed between Greystone and Jamesburg.

(b) Results: The test results are shown in Table 6. The Greystone to Jamesburg link covered 36.5 miles (58.7 Km). As can be seen from the data, the results were excellent. These results show that reliable sensor data link with the MINI-SID antenna can exist for greater than 50 Km as long as RF line-of-sight is provided.

(2) Budd Lake to Jamesburg:

(a) Location: These tests were conducted with a Keyer using a SIRR antenna located at Budd Lake, and the AN/USQ-46 using a 30-foot antenna at Jamesburg. ECAC data showed that the above link was marginal.

(b) Results: The test results are shown in Table 7a. Using a MINISID antenna during Run 1 resulted in poor data. For the remaining tests, the MINISID antenna was replaced with the SIRR omni-directional antenna having VSWR of no more than 1.21. The results of the test verify the Configuration C results in Table 4 and 5. The importance of having reliable equipment (i.e., antennas, etc.) is also shown.

Run	Greystone: Keyer or Test Set/Count	Greystone: EXRAY 3	Jamesburg AN/USQ-46 VMC/Count	Link Reliability %
1	Keyer (30 ft. Spike Ant.)/500	Not Used	OP/500	100.0
2	Test Set (30 ft. Spike Ant.)/500	EXRAY 3/30 ft. Spike Ant.	OP/483	96.6
3	Keyer #1 w/Mini-sid Ant./500	Not Used	OP/460	92.0
4	Keyer #1 w/Mini-sid Ant./200	Not Used	OP/189	94.5
5	Test Set (30' Spike)/500	EXRAY 3/10 ft. Spike Ant.	OP/480	96.8
6	Keyer #2 w/Mini-sid Ant./220	Not Used	OP/220	100.0
7	Keyer #2 w/Mini-sid Ant./220	Not Used	OP/208	94.5

TABLE 6: Supplemental Tests - Greystone to Jameburg Test Results

Run	Budd Lake Keyer/Count	Jamesburg AN/USQ-46 VMC	Link Reliability
1	OP/Minisid Antenna 200	OP/92	46.0%
2	OP/SIRR Antenna 100	OP/97	97.0%
3	SI/SIRR Antenna 190	OP/190	100.0%
4	E1/SIRR Antenna 200	OP/0	0.0%
5	N.5/SIRR Antenna 200	OP/0	0.0%
6	W1/SIRR Antenna 50	OP/0	0.0%

TABLE 7a: Supplemental Tests - Budd Lake to Jamesburg Test Configuration (A)

(3) Budd Lake to Greystone to Jamesburg:

(a) Location: These tests were conducted with a Keyer located at Budd Lake, an EXRAY with a 22 foot antenna located at Greystone, and an AN/USQ-46 using a 30 foot antenna located at Jamesburg. ECAC data showed that RF line-of-sight existed between both links.

(b) Results: The test results are shown in Table 7b. The distance between Budd Lake and Greystone was 12.8 miles (20.6 Km) and the distance between Greystone and Jamesburg was 36.5 miles (58.7 Km) for a total distance of 49.3 miles (79.3 Km). For Run 1, the Keyer, using the Spike antenna set at 30 feet, and for Run 2, the Spike antenna was at 10 feet. EXRAY 2 Spike antenna was 22 feet high. Later, it was found that the battery in the Keyer was low, resulting in a low keyer RF output power. In spite of this, Run 1 showed that a 79 Km, one relay link can be obtained.

(4) Milton to Greystone to Jamesburg:

(a) Location: These tests were conducted with a Keyer located at Milton, EXRAY 2 at Greystone using a 22 foot antenna, and the AN/USQ-46 at Jamesburg using a 30 foot SIRR antenna. ECAC data showed that RF line-of-sight existed between both links. (See Appendix C4).

(b) Results: The results are shown in Table 8. The distance between Milton and Greystone was 10.7 miles (17.2 Km) and the distance between Greystone and Jamesburg was 36.5 mi (58.7 Km) for a total distance of 53.7 miles (75.8 Km). From the table, it is seen that using the better antenna (low VSWR) at the Keyer resulted in better reliability. The data verified that reliable data can be obtained for distances greater than 50 Km if RF line-of-sight is provided. For Runs 1 and 3, the Keyer used the SIRR antenna. For Run 3, the Keyer was placed upright and had a MINISID antenna. For Run 4, the Keyer was placed horizontally but used a vertical MINISID antenna (see Fig. 3).

Flat Terrain Tests:

a. Flat Terrain Relay and Sensor (Keyer) Site Descriptions:

(1) Sensor (Keyer) Sites: Flat terrain sensor sites were established in the Ocean and Bulington County Pine Barrens of New Jersey. The Apple Pie Area consisted of fifteen sites located along Route 532, between Chatsworth and Tabernacle. They varied in distance from 10.4 miles (16.8 Km) to 19.7 miles (31.8 Km) from the Cedar Bridge Relay/Monitor site. Nine additional sites were located along Route 539 between Warren Grove and the Garden State Parkway. The Warren Grove sites varied in distance from 6.8 miles (10.15 Km) to 12.5 miles (20.1 Km) from Cedar Bridge. Site diagram and photographs are found in Appendices B1-B5.

Run	Budd Lake Keyer/Count	Greystone EXRAY 2	Jamesburg AN/USQ-46 VMC/Count	Link Reliability
1	OP (30' Spike)/200	OP	OP/195	97.5%
2	OP (10' Spike)/50	OP	OP/0	0.0%

TABLE 7b: Supplemental Tests - Budd Lake to Greystone to Jamesburg Test Results

Run	Milton Keyer/Count	Greystone EXRAY 2	Jamesburg AN/USQ-46	Link Reliability
1	OP w/SIRR Antenna/200	OP	OP/170	85.0%
2	OP w/SIRR Antenna/200	OP	OP/163	81.5%
3	OP w/Minisid Antenna (Keyer Vertical)/200	OP	OP/152	76.0%
4	OP w/Minisid Antenna (Keyer Horizontal)/500	OP	OP/266	53.2%

TABLE 8: Supplemental Tests - Milton to Greystone to Jamesburg Configuration (B)

(2) Relay Site Description:

(a) Cedar Bridge Fire Tower Test Site (200'/61M): The site is located in the Pine Barren Section of Lacey Township (south of Lakehurst, 2 miles (3.2 Km) east of Route 539). The area is completely covered by small pines (15-25 ft) and scrub oak (6-10 ft). Cedar Bridge served as a monitor and relay test site. Site diagram and photographs are found in Appendices B6-B9.

(b) Lakewood Fire Tower Test Site (150'/46M): The site is located on Massachusetts Avenue, West of Rt 9, in Lakewood, NJ. Lakewood served as a relay test site. Site diagram and photographs are found in Appendices B10-B11.

(c) Evans Test Site (80'/24M): The site was located within the CSTA Laboratory, Camp Evans Area, Belmar, New Jersey. Evans served as a monitor test site. The site diagram is found in Appendix B12.

(d) Oakhurst Test Site (200'/61M): The site is located west of Rt 35, in Ocean Township, New Jersey. The area is owned by the U.S. Army and serves as a test site for numerous ECOM projects. During the data link tests, Oakhurst served as a relay test site. The site diagram and photographs are found in Appendices B13-B15.

(e) Jamesburg Fire Tower Test Site: Site details are found in Appendices A17-A19.

b. Sensor-to-Monitor Tests (Configuration A):

(1) Location: These tests were conducted with the Keyer located at both the Apple Pie Test site along New Jersey Route 532 and at Warren Grove Test Site, along New Jersey Route 539. The monitor was located at the Cedar Bridge Test site optimum point. The degree of RF shielding chart showing RF line-of-sight for 10 and 30 foot antennas at the Cedar Bridge Test Site showed that RF line-of-sight did not exist to the Apple Pie Keyer sites. ECAC data is shown in Appendix C9. Though ECAC data was not requested for Warren Grove, the link between Warren Grove Test site and Cedar Bridge was at best a marginal RF line-of-sight.

(2) Results: The Apple Pie Test results are shown in Table 9a. The variation in the results are probably due to not having RF line-of-sight. In addition, it was also observed that the position of the operator and/or nearby natural objects acting as a reflective or directive element to the Keyer antenna, had a significant effect. However, care was taken so as not to affect the results.

In looking at Table 9a, certain Keyer sites have been further defined as to the side of the road the Keyer was positioned to (i.e., K6N means that Keyer was located on the

RUN	APPLE PIE KEYER/COUNT	LINK DISTANCE	CEDAR BRIDGE AN/USQ-46/COUNT	LINK RELIABILITY
1	K1/100	10.4 mi (16.7 Km)	OP/88	88.0%
2	K1/500	" " "	OP/500	100.0%
3	K2N/500	11.1 mi (17.85 Km)	OP/133	26.0%
4	K2S/200	" " "	OP/200	100.0%
5	K3N/500	12 mi (19.3 Km)	OP/485	97.0%
6	K4S/200	12.8 mi (20.6 Km)	OP/199	99.5%
7	K5S/300	13 mi (20.9 Km)	OP/110	36.6%
8	K5N/500	" " "	OP/451	90.2%
9	K6N/200	13.1 mi (21.1 Km)	OP/6	3.0%
10	K6S/200	" " "	OP/18	9.0%
11	K6S/200	" " "	OP/200	100.0%
12	K6S/258	" " "	OP/258	100.0%
13	K6N/200	" " "	OP/180	90.0%
14	K6N/50	" " "	OP/0	0%
15	K6S/200	" " "	OP/187	93.5%
16	K6N/200	" " "	OP/17	3.5%
17	K6N/200	" " "	OP/3	1.5%
18	K6N/200	" " "	OP/189	94.5%
19	K6N/200	" " "	OP/151	75.5%
20	K6N/200	" " "	OP/41	20.5%
21	K7N/200	14.5 mi (23.3 Km)	OP/30	15.0%
22	K7N/200	" " "	OP/200	100.0%
23	K7S/90	" " "	OP/84	93.3%
24	K8N/200	15.2 mi (24.5 Km)	OP/200	100.0%
25	K9N/200	15.8 mi (25.4 Km)	OP/183	91.5%
26	K10N/200	16.4 mi (26.4 Km)	OP/200	100.0%
27	K11N/200	17 mi (27.4 Km)	OP/200	100.0%
28	K12N/200	17.8 mi (28.6 Km)	OP/200	100.0%
29	K13N/200	18.1 mi (29.1 Km)	OP/200	100.0%
30	K14N/200	18.8 mi (30.3 Km)	OP/4	2.0%

TABLE 9a: APPLE PIE TO CEDAR BRIDGE SENSOR-TO-MONITOR TEST RESULTS

north side of the road at point K6). Keyer 1 was used with the MINISID antenna, except for the following Runs:

(a) Run 11, a vertical SIRR antenna was used;

(b) Run 12 and 13, Keyer 1 was replaced with Keyer 2, using the MINISID antenna;

(c) Run 17, Keyer 1, was replaced with Keyer 2;

(d) Run 18, the Toss Up antenna was used with Keyer 2;

(e) Run 19, Keyer 1 used the Toss Up antenna;

(f) Runs 20 and 22 through 29, a vertical SIRR antenna was used. Notice the improved performance by using a better (low VSWR) antenna.

Though some of the test results were good, non-RF line-of-sight sensor-to-monitor links over long distances (greater than 15 Km) were basically unreliable when the Keyer was used with the MINISID antenna. Excellent performance was demonstrated when the Keyer was used with the low VSWR SIRR antenna giving distances up to 39 Km. Use of an antenna of this type would not normally be the case however, due to its bulk and lack of portability.

The Warren Grove Test results are shown in Figure 9b. For a marginal RF line-of-sight situation, the results were excellent. For Runs 4 and 5, the Keyer was in a slight depression. The Keyer was used with the MINISID antenna throughout these tests.

c. Sensor-to-Relay-to-Monitor Test (Configuration B):

(1) Location: These tests were conducted in two stages; first, the Keyer and EXRAY 1 were located at Cedar Bridge, and, second, with the Keyer located at Warren Grove (K2). EXRAY 1 was located at Cedar Bridge and the monitor was at Lakewood. For both cases, EXRAY 1 and its spike antenna were positioned at Cedar Bridge optimum point and at each offset point. Two runs were conducted for each EXRAY position with spike antenna at heights 10 and 30 feet. The AN/USQ-46 was located at the Lakewood Test Site optimum point. The 4/3 Earth terrain profiles representing the RF propagation path for EXRAY to monitor link shows that RF line-of-sight exists between Cedar Bridge and Lakewood optimum points. ECAC data is in Appendix C6.

(2) Results: The test results are shown in Tables 10a and 10b, for the Cedar Bridge to Lakewood tests, and Tables 10c and 10d for Warren Grove to Cedar Bridge to Lakewood Tests. The distance between Cedar Bridge and Lakewood is 17.6 miles (28.4 Km). As expected, the results were excellent. For

Run	Waren Grove Keyer/Count	Link Distance/Miles	Cedar Bridge AN/USQ-46/Count	Link Reliability
1	K1/200	5.9 mi. (9.5 Km)	OP/200	100.0%
2	K2/200	6.6 mi. (10.6 Km)	OP/200	100.0%
3	K3/200	7.2 mi. (11.6 Km)	OP/200	100.0%
4	K4/200	7.8 mi. (12.5 Km)	OP/43	21.5%
5	K5/200	8.5 mi. (13.7 Km)	OP/200	100.0%
6	K6/200	9.0 mi. (14.5 Km)	OP/195	97.5%
7	K7/200	9.7 mi. (15.6 Km)	OP/158	79.0%
8	K8/200	10.2 mi. (16.4 Km)	OP/200	100.0%

TABLE 9b: Warren Grove Area Test Configuration (A)

Run	Cedar Bridge Keyer/Count	Cedar Bridge EXRAY 1 VMC/Count	Lakewood AN/USQ-46/ Count	Link Reliability
1	Cedar Bridge/500	OP/500	OP/500	100.0%
2	Cedar Bridge/500	E1/500	OP/500	100.0%
3	Cedar Bridge/500	W1/500	OP/473	94.6%
4	Cedar Bridge/500	S1/500	OP/496	99.2%
5	Cedar Bridge/500	N1/500	OP/492	98.4%

TABLE 10a: Cedar Bridge to Lakewood (One Relay) Test Results Using 10 Foot Spike Antenna

Run	Cedar Bridge Keyer/Count	Cedar Bridge EXRAY 1 VMC/Count	Lakewood AN/USQ-46 Count	Link Reliability
1	Cedar Bridge/500	OP/500	OP/500	100.0%
2	Cedar Bridge/500	E1/500	OP/494	98.8%
3	Cedar Bridge/500	W1/500	OP/500	100.0%
4	Cedar Bridge/500	S1/500	OP/473	94.6%
5	Cedar Bridge/500	N1/500	OP/500	100.0%

TABLE 10b: Cedar Bridge to Lakewood (One Relay) Test Results Using 30 Foot Spike Antenna

Tables 10c and 10d, Column A represents the reliability of the Keyer-to-EXRAY 1 link (6.3 miles/10.1 Km). Column B represents the reliability of the EXRAY 1 to monitor link (17.6 miles/28.4 Km). Column C represents the overall link reliability (23.9 miles/38.5 Km). As expected, raising the EXRAY antenna to 30 feet improved link reliability. No result is available for Run 5, Table 10c, due to VMC failure, and no spares were immediately available at the site.

d. Sensor Through Two (2) Relays to Monitor Test (Configuration C):

(1) Location: These tests were conducted with the Keyer located at Cedar Bridge. EXRAY 1 was also located at Cedar Bridge and EXRAY 2 with VMC was located at the Lakewood OP and each offset point. At least two runs were conducted for each EXRAY 2 position with spike antenna at heights of 10 and 30 feet. The monitor was located at Camp Evans using a 30 foot antenna. The 4/3 earth terrain profiles representing the RF propagation path for the EXRAY to monitor link showed that RF line-of-sight did not exist between Lakewood and Camp Evans. The ECAC data is in Appendix C7.

(2) Results: The test results are shown in Figs. 11a and 11B. Column A represents the reliability of the Keyer through EXRAY 1 to EXRAY 2 link (17.6 miles/28.4 Km). Column B represents the reliability of the EXRAY 2 to monitor link (11.6 miles/18.7 Km). Column C represents the reliability of the overall link (29.3 miles/47.1 Km). Due to the poor results of the Cedar Bridge to Lakewood Link (see Table 11a) the EXRAY 1 antenna was raised to 15 feet for Run 2, then to 20 feet for Run 3, and to 30 feet for the remaining Runs. EXRAY 2 was raised to 18 feet for Runs 6-8. It is expected but not verified that the receiver sensitivity of EXRAY 2 was low since previous tests showed the Cedar Bridge to Lakewood link reliable. The Lakewood to Camp Evans non-RF line-of-sight link was reliable (11.6 mi/18.7 Km). As shown in Table 11b, with both EXRAY antenna at 30 feet, the results were excellent.

CONCLUSIONS

Test Objectives: To aid in the appreciation of the Field Test results, the objectives of the Field Test are repeated below:

a. To demonstrate that a sensor-to-monitor link can be implemented over a nominal distance of 9.5 miles (15 Km) in both hilly and flat, vegetated terrains.

b. To demonstrate that a multihop sensor data link can be implemented to cover a distance of greater than 31 miles (50 Km) in both hilly and flat, vegetated terrains.

c. To simulate the effects on the data links performance associated with emplacement errors.

Run	Warren Grove Keyer/Count	Cedar Bridge EXRAY 1 Count	Lakewood AN/USQ-46/Count	Link Reliabilities		
				A	B	C
1	K2/200	OP/131	OP/130	65.5%	99.2%	65.5%
2	K2/200	W1/180	OP/169	90.0%	93.8%	84.5%
3	K2/200	S1/132	OP/132	66.0%	100.0%	66.0%
4	K2/200	N1/19	OP/18	9.5%	94.7%	9.5%
5	K2/200	E1/196	OP/No Count	98.0%	N/A	N/A

TABLE 10c: Cedar Bridge to Lakewood (One Relay) Test Results Using 10 Foot EXRAY Spike Antenna with Keyer at Warren Grove

Run	Warren Grove Keyer/Count	Cedar Bridge EXRAY 1 Count	AN/USQ-46/Count	Link Reliabilities		
				A	B	C
1	K2/200	OP/199	OP/199	99.5%	100.0%	99.5%
2	K2/200	E1/200	OP/200	100.0%	100.0%	100.0%
3	K2/200	W1/200	OP/197	100.0%	98.5%	98.5%
4	K2/200	S1/200	OP/200	100.0%	100.0%	100.0%
5	K2/200	N1/160	OP/160	80.0%	100.0%	80.0%

TABLE 10d: Cedar Bridge to Lakewood (One Relay) Test Results Using 30 Foot EXRAY Spike Antenna with Keyer at Warren Grove

Run	Cedar Bridge Keyer/EXRAY 1/ Count	Lakewood EXRAY 2/ Count	Camp Evans AN/USQ-46/ Count	Link Reliabilities		
				A	B	C
1	200	OP/73	OP/71	36.5%	97.3%	35.5%
2	200	OP/74	OP/74	37.0%	100.0%	37.0%
3	200	OP/169	OP/169	84.5%	100.0%	84.5%
4	200	E1/147	OP/147	73.5%	100.0%	73.5%
5	200	S1/0	0	0%	0%	0%
6	200	S1/130	OP/130	65.0%	100.0%	65.0%
7	200	W1/200	OP/200	100.0%	100.0%	100.0%
8	200	N1/10	OP/10	5.0%	100.0%	5.0%

TABLE 11a: Cedar Bridge to Lakewood to Evans (2 Relay) Test Results Using 10 Foot EXRAY Spike Antenna

Run	Cedar Bridge Keyer/EXRAY 1/ Count	Lakewood EXRAY 2/ Count	Camp Evans AN/USQ-46/ Count	Link Reliabilities		
				A	B	C
1	50	OP/50	OP/50	100.0%	100.0%	100.0%
2	200	OP/200	OP/200	100.0%	100.0%	100.0%
3	200	E1/200	OP/200	100.0%	100.0%	100.0%
4	200	S1/200	OP/199	100.0%	99.5%	99.5%
5	200	N1/200	OP/197	100.0%	98.5%	98.5%
6	200	W1/200	OP/160	100.0%	80.0%	80.0%
7	200	OP/200	OP/200	100.0%	100.0%	100.0%
8	500	OP/500	OP/497	100.0%	99.4%	99.4%

TABLE 11b: Cedar Bridge to Lakewood to Evans (2 Relays) Test Results Using 30 Foot EXRAY Spike Antenna

d. To simulate operational and proposed sensor data link models using various antenna heights.

Accomplishments and Results: Though limited in time, this program has provided a clear picture of the performance reliability of a sensor data transmission system deployed in both flat and hilly terrain. All of the above objectives were accomplished and the results are as follows:

a. Hilly Terrain:

(1) For distances up to 21 Km it was demonstrated that the sensor-to-monitor data link performed reliably when RF line-of-sight existed.

(2) For distances up to 76 Km, it was demonstated that multihop sensor data links performed reliably when RF line-of-sight existed between links.

(3) The value of a high antenna and the effects on data link performance associated with emplacement errors were demonstrated. It was found that if RF line-of-sight between individual link OP's was the case, a reliable link normally could be established by raising the antenna to 30 feet at the offset points.

(4) If RF line-of-sight existed it was demonstrated that reliable sensor-to-monitor links can be obtained with the MINISID sensor antenna for distances up to 20.9 Km.

b. Flat Terrain:

(1) For distances up to 29 Km, it was demonstrated that the sensor-to-monitor data link performed reliably when SIRR low loss antenna was used even if RF line-of-sight did not exist. However, when the MINISID antenna was used, the reliability of the data link degraded, except for short distances of about 9.5 to 16.4 Km, where no such degradation in reliability occurred.

(2) For distances up to 47 Km, it was demonstrated that multihop sensor data links performed reliably even if the relay-to-monitor link (with 30 foot antennas) did not have RF line-of-sight.

(3) An attempt was made to conduct a three EXRAY, multihop test from Warren Grove to Jamesburg, via Cedar Bridge, Lakewood and Oakhurst. The results were inconclusive as mentioned in Para. c, pg 13, due to decoder logic problems in EXRAY 3 at Oakhurst.

RECOMMENDATIONS

The following recommendations are presented as a result of the effort involved in preparing for the field program, the

field test results, and the analysis of the test data and subsequent ECAC site analyses and terrain profiles.

Prior to implementing a sensor data transmission system, all equipment should be checked against specifications to ensure maximum system performance (e.g., receiver sensitivity, transmitter output power, etc).

In selecting relay sites, maximum use of highest terrain should be of paramount consideration in line with the mission and concealment objectives. Where the possibility of RF terrain masking exists, great care should be exercised in the emplacement phase to minimize the effect of offset errors.

Any future testing of sensor data transmission systems should follow the data collection concept developed during this program. Some type of valid message counter should be employed at each data link component location.

ECAC's services should be utilized during sensor investigative programs, training and actual tactical exercises to insure that RF line-of-sight exists when selecting sites. The RF shielding charts and terrain profiles are valuable tools in implementing reliable sensor data transmission. (NOTE: The ECAC study was completed after the field tests, therefore the charts and profiles were not available at the time of the tests).

For future testing, the test ranges established in Pennsylvania and New Jersey should be utilized. This is suggested because of its availability and of the extensive data compiled during the pre-test surveying and the subsequent ECAC's site analysis and profiling.

ACKNOWLEDGEMENTS

This program could not have been accomplished without the support of the following individuals and organizations. We wish to express our appreciation and hereby acknowledge their support:

Field Test Support Personnel:

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Mr. Robert Volmer	" " " "
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Mr. Clifford Hogan	"
SP4 G. Zimmerman	Atmospheric Sciences Lab
SP4 R. Karnaz	" " "

Equipment Design/Fabrication:

Mr. Charles Burkett	CS&TA Lab, Ft Monmouth
Mr. Edmond Randolph (Ret)	" " " "

Surveying/Drafting:

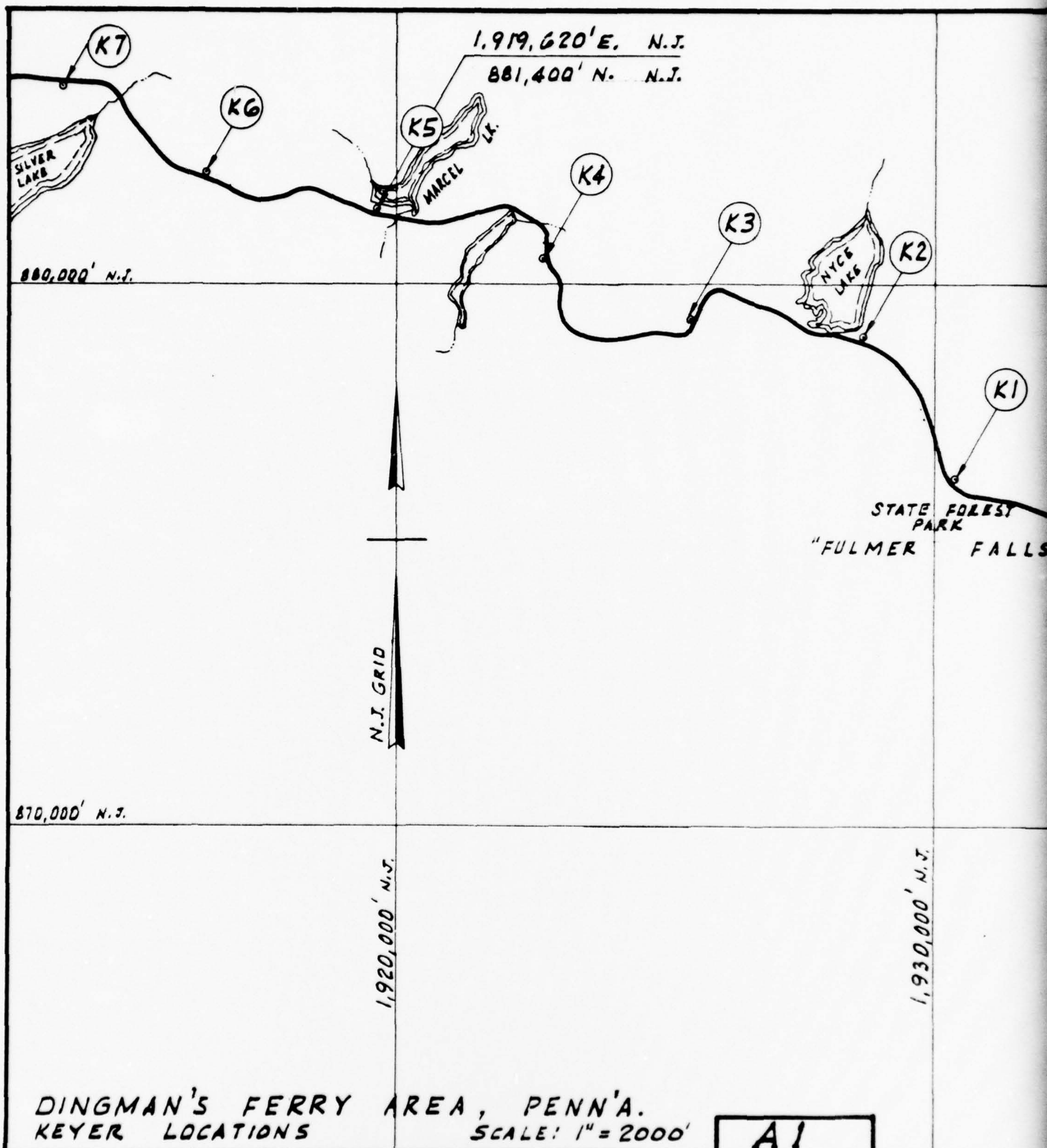
Mr. Daniel Brennan R&DTSA

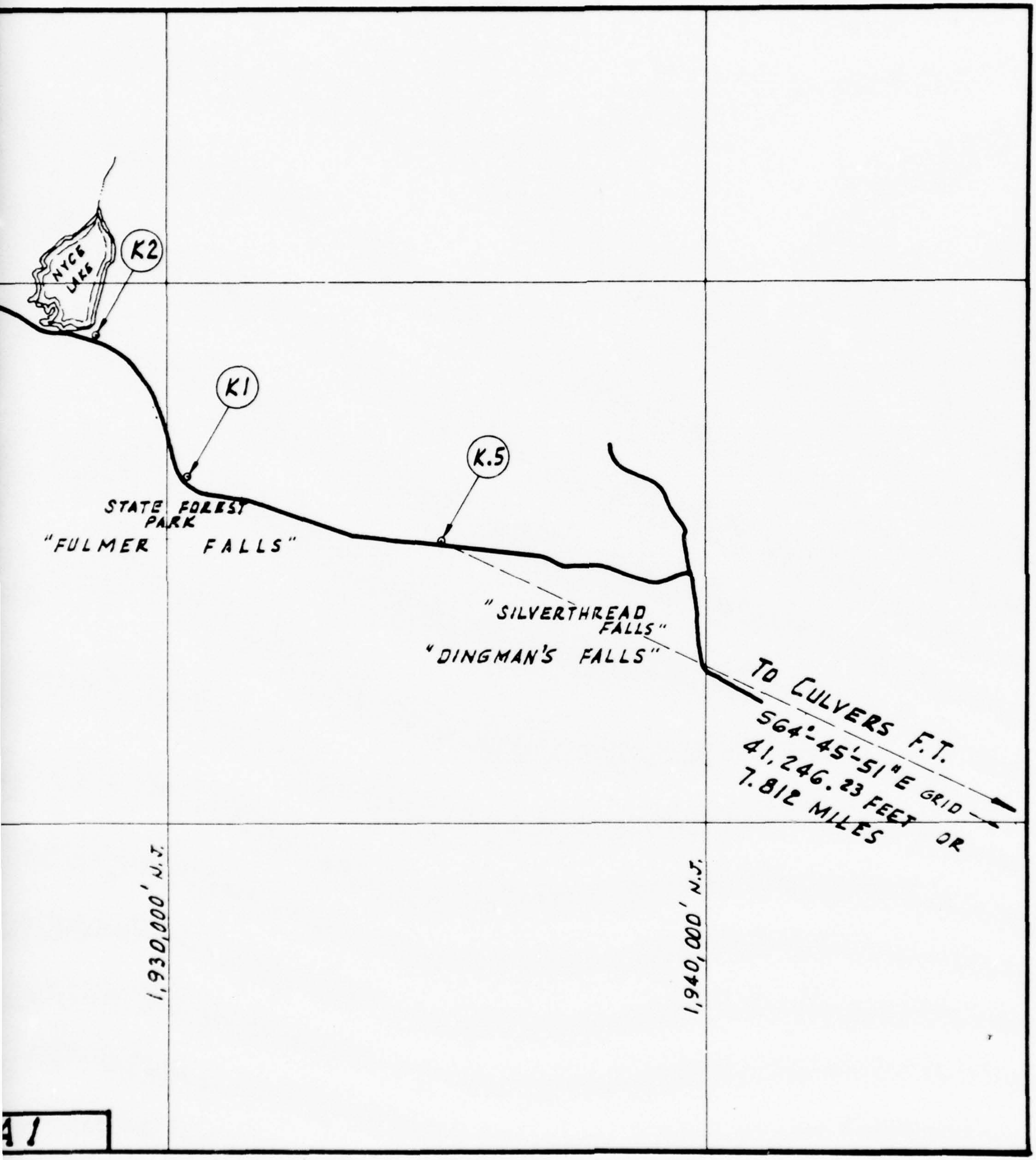
New Jersey State Environmental Protection Agency
Division of Forest Fire Service
Trenton, NJ

PM-REMBASS, Fort Monmouth, NJ

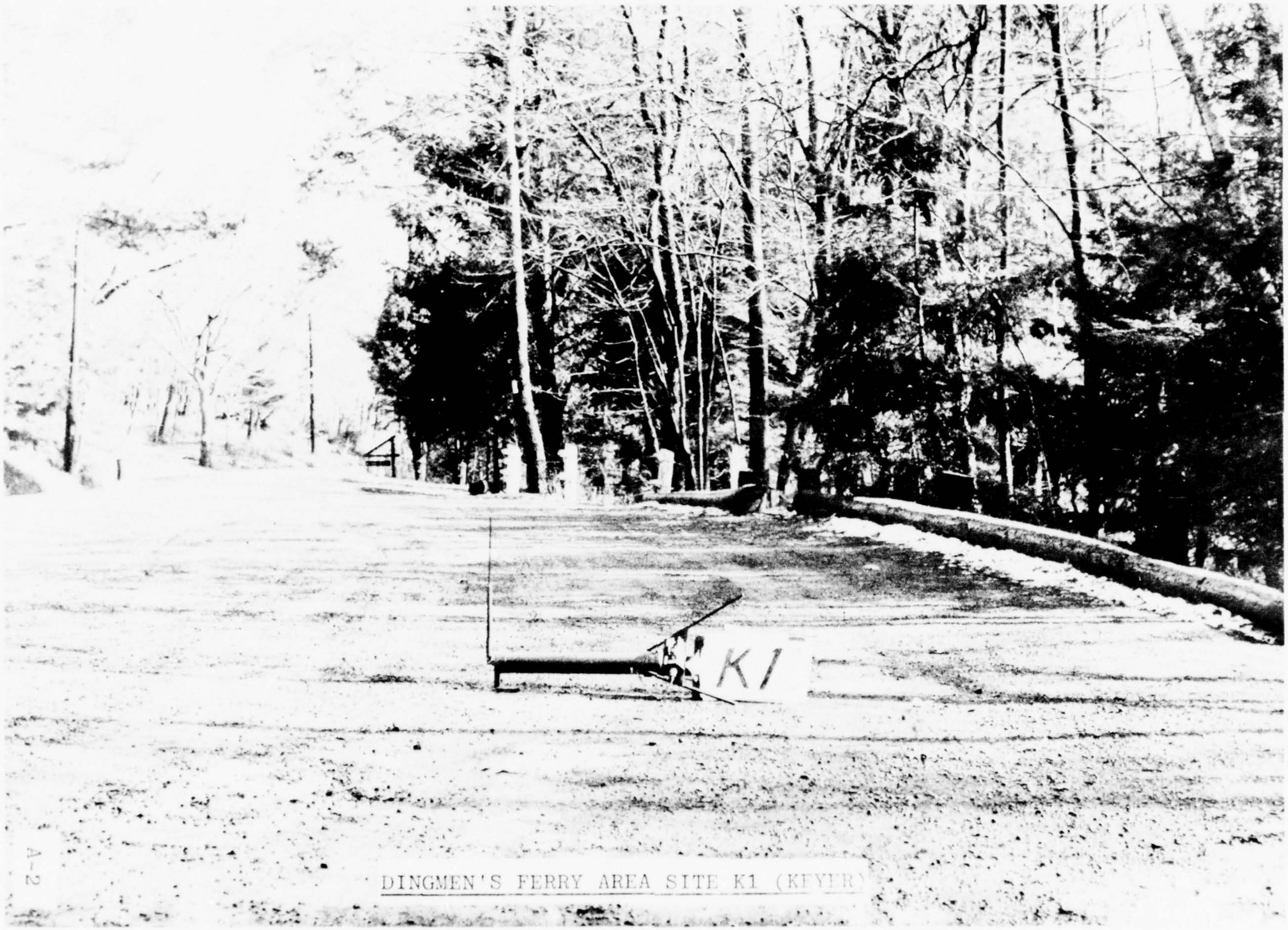
APPENDIX A

HILLY TERRAIN TEST SITE INFORMATION

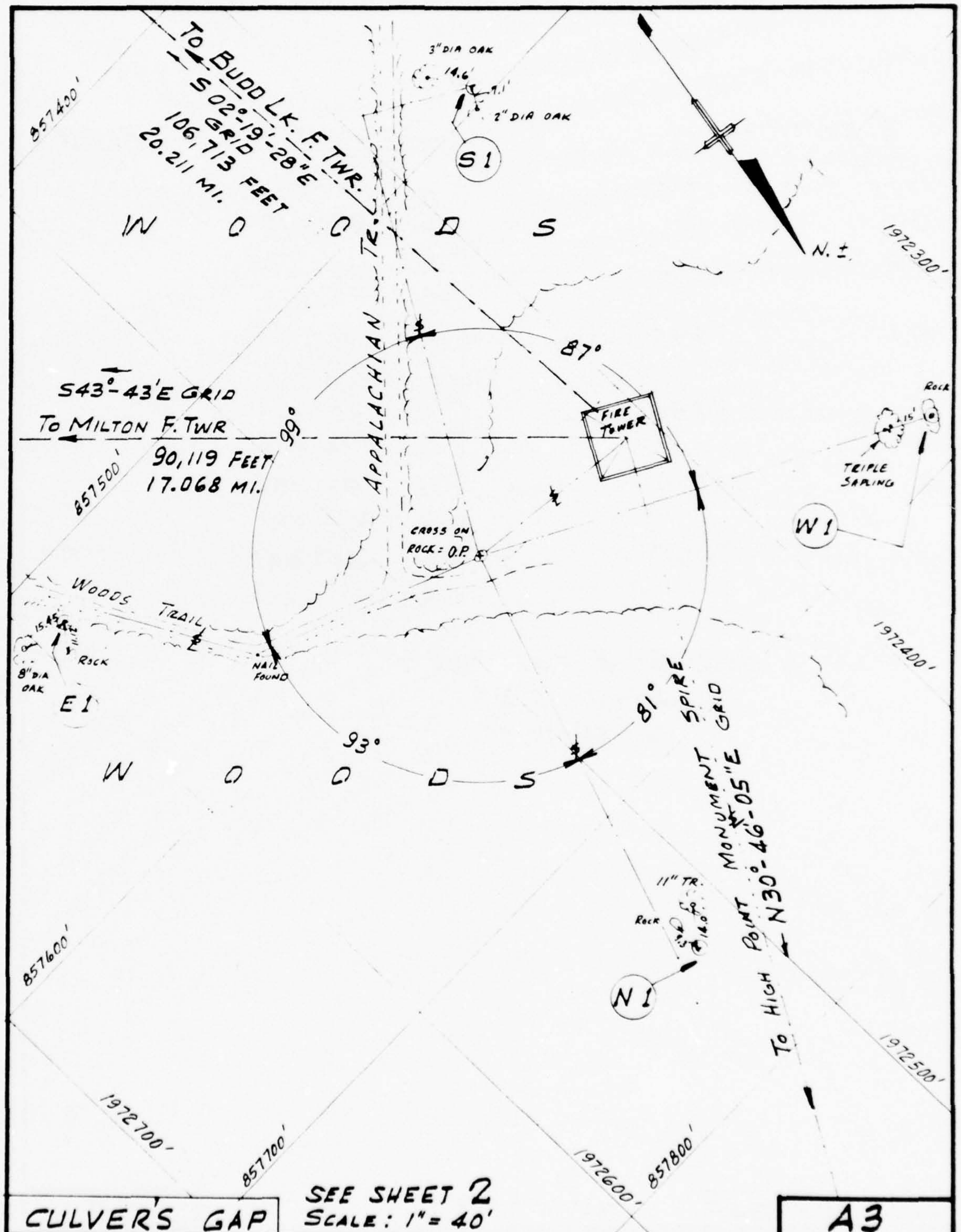

K7
K6
K5
K4
K3
K2
K1
1,919,620'E. N.J.
881,400' N. N.J.
SILVER LAKE
MARCEL LK.
NYCE LAKE
880,000' N.J.
870,000' N.J.
N.J. GRID
STATE FOREST PARK
"FULMER FALLS
1,920,000' N.J.
1,930,000' N.J.
DINGMAN'S FERRY AREA, PENN'A.
KEYER LOCATIONS
SCALE: 1" = 2000'
A1


NYCE LAKE
K2
K1
K.5
STATE FOREST PARK
"FULMER FALLS"
"SILVERTHREAD FALLS"
"DINGMAN'S FALLS"
TO CULVERS F.T.
S64°-45'-51"E GRID
41,246.23 FEET OR
7.812 MILES
1,930,000' N.J.
1,940,000' N.J.
A1

2



DINGMEN'S FERRY AREA SITE K1 (KEYER)

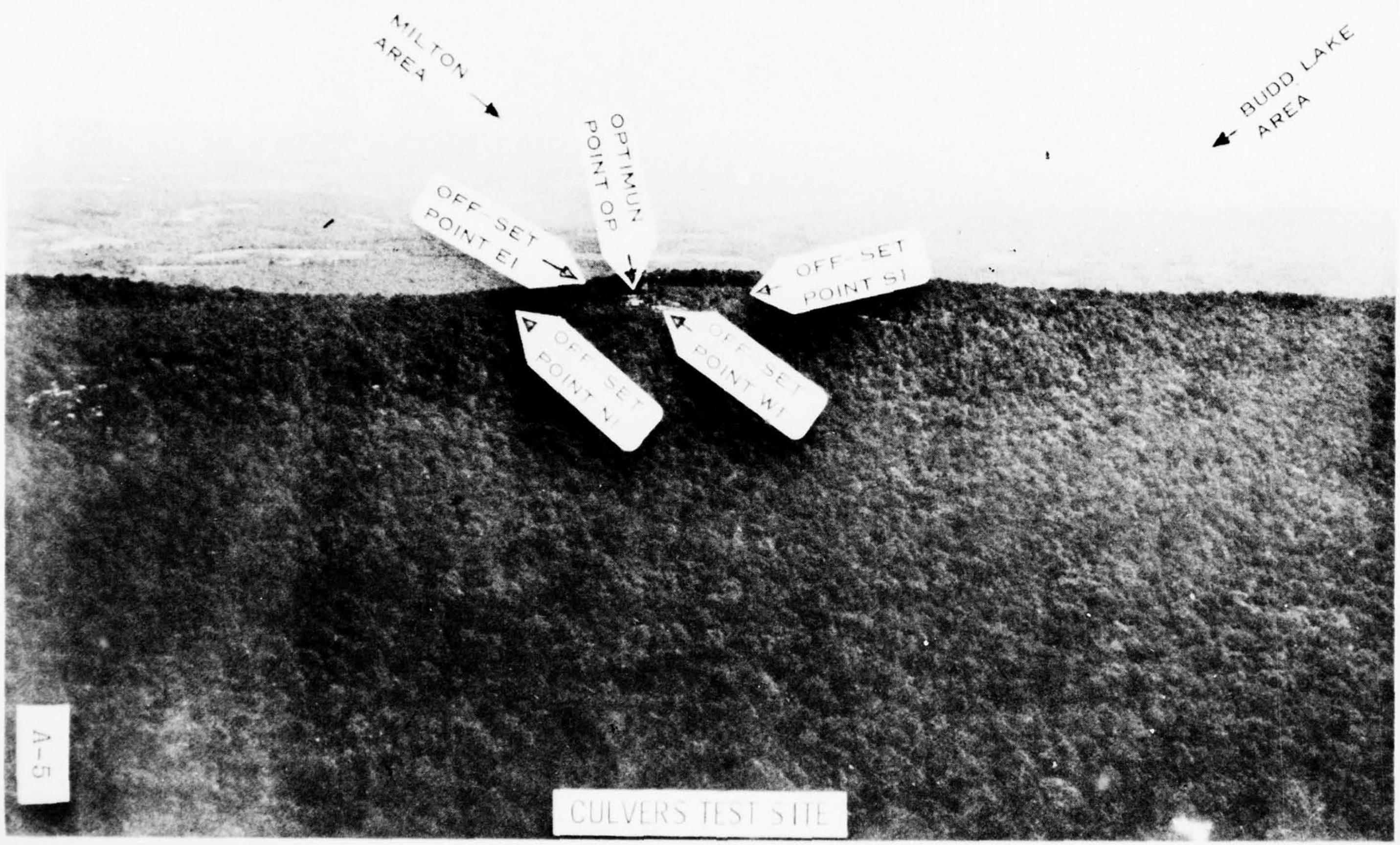


To BUDD LK. F. TWR.
S 02°-19'-28"E GRID
106,713 FEET
20.211 MI.
3" DIA OAK
14.6'
2" DIA OAK
S1
W O O D S
N.
APPALACHIAN TR.
87°
S43°-43'E GRID
To MILTON F. TWR
90,119 FEET
17.068 MI.
99°
FIRE TOWER
ROCK
TRIPLE SAPLING
W1
CROSS ON ROCK = O.P.
WOODS TRAIL
8" DIA OAK
ROCK
E1
NAIL FOUND
93°
81°
W O O D S
To HIGH POINT MONUMENT SPIRE
N30°-46'-05"E GRID
11" TR.
ROCK
N1
857400'
857500'
857600'
857700'
857800'
1972300'
1972400'
1972500'
1972600'
1972700'
CULVER'S GAP
SEE SHEET 2
SCALE: 1" = 40'
A3

ELEVATIONS		COORDINATES (N.J. PLANE)
FIRE TWR.	1515'	N. 857,615' E. 1,972,410'
O.P.	1512'	N. 857,607' E. 1,972,473'
N I	1495'	N. 857,753' E. 1,972,519'
E I	1485'	N. 857,519' E. 1,972,588'
S I	1510'	N. 857,494' E. 1,972,361'
W I	1501'	N. 857,685' E. 1,972,333'

LAT. & LONG. @ ℄ FIRE TWR.:
41°-11'-15.6"
74°-46'-00.5"

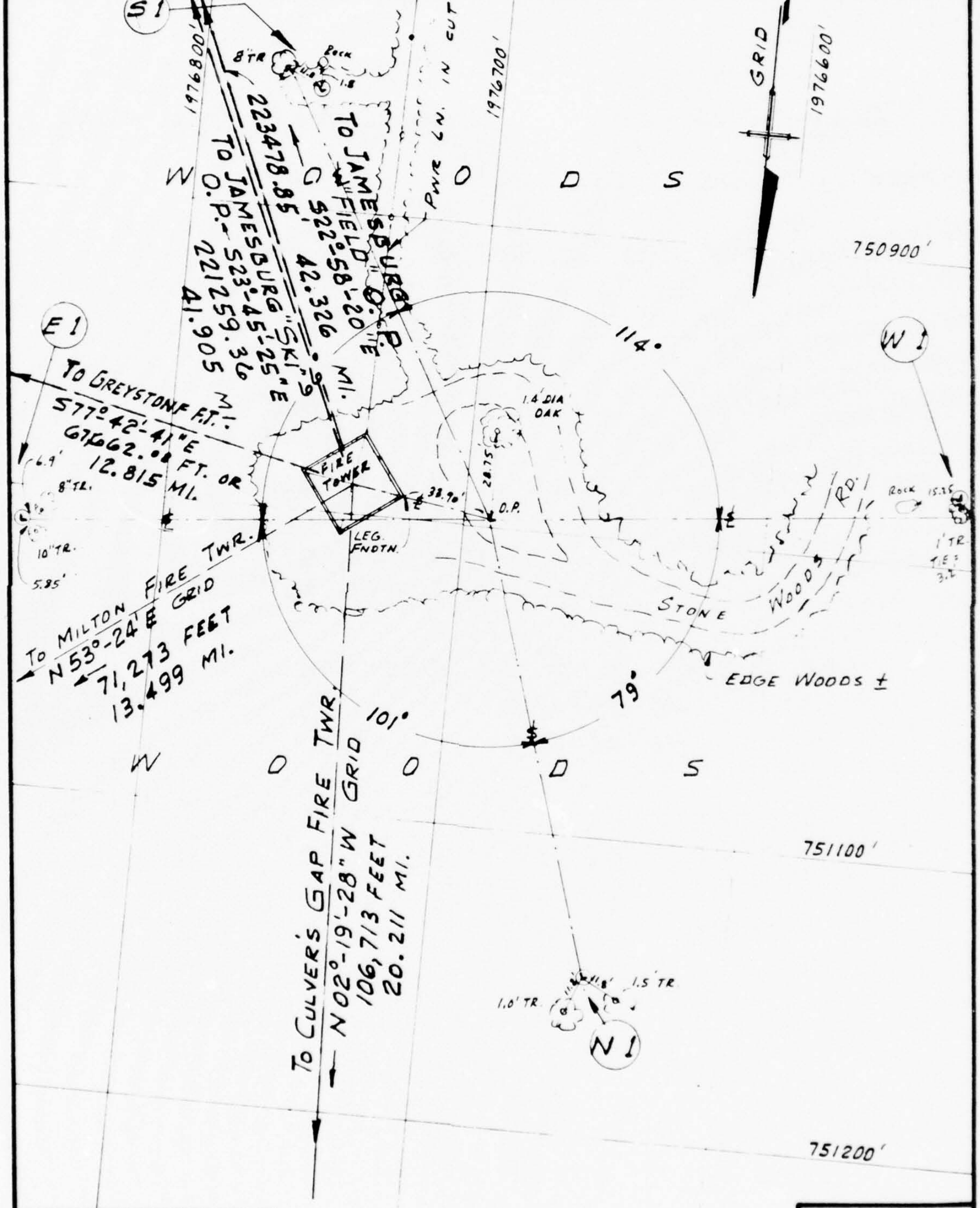
CULVER'S GAP SHEET 2 A4



MILTON AREA
OPTIMUN POINT OP
BUDD LAKE AREA
OFF-SET POINT E1
OFF-SET POINT S1
OFF-SET POINT N1
OFF-SET POINT W1
A-5
CULVERS TEST SITE

CULVER'S OFFSET W1 - 30 FOOT SPIKE ANTENNA

A-6



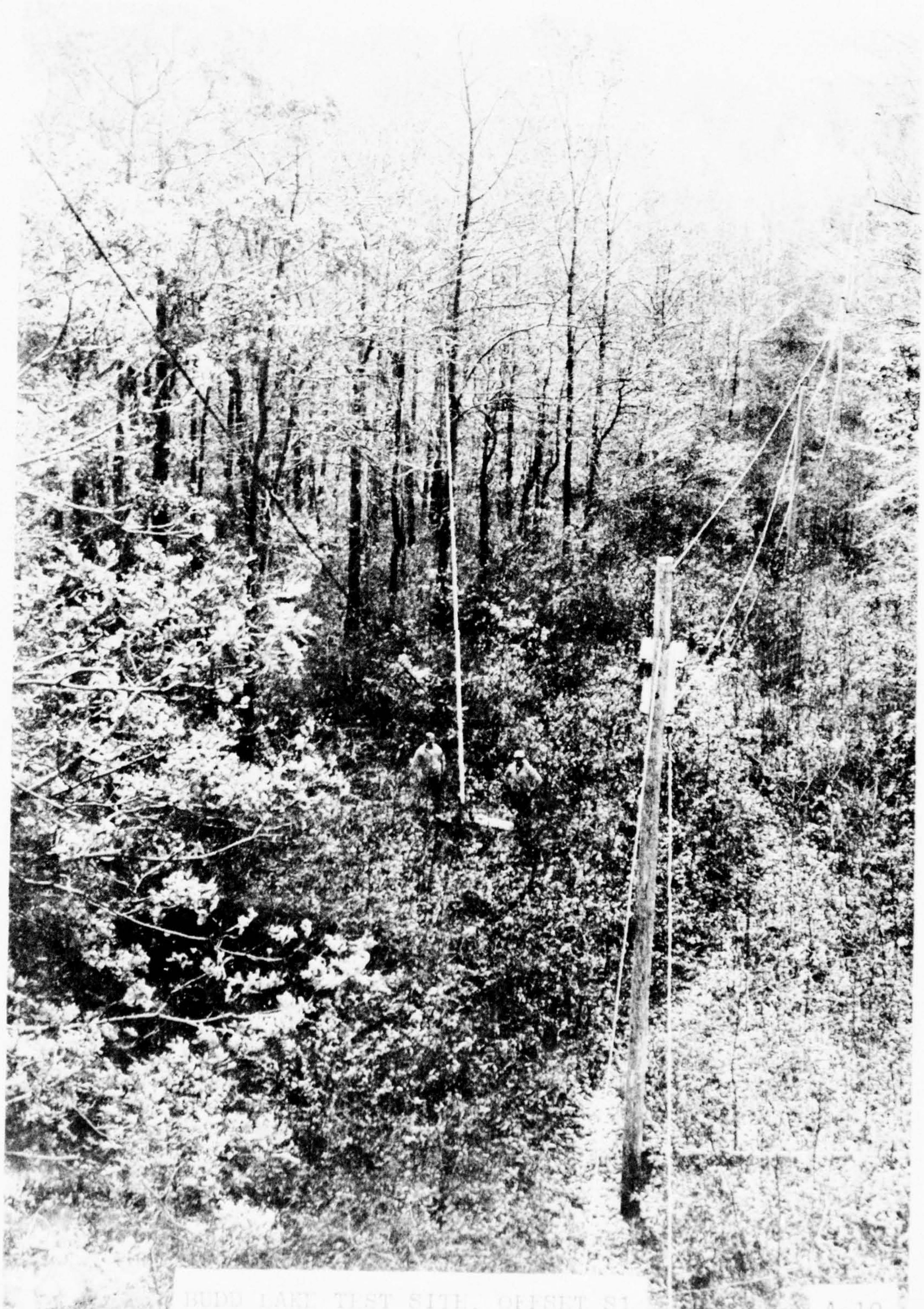
BUDD LAKE | SCALE: 1" = 40' | SEE SHEET 2 | A7

ELEVATIONS		COORDINATES (N.J. PLANE)
FIRE TWR.	1210'	N. 750,990' E. 1,976,738'
O.P.	1208'	N. 750,997' E. 1,976,692'
N 1	1176'	N. 751,147' E. 1,976,646'
E 1	1206'	N. 751,012' E. 1,976,847'
S 1	1213'	N. 750,861' E. 1,976,760'
W 1	1173'	N. 750,977' E. 1,976,537'

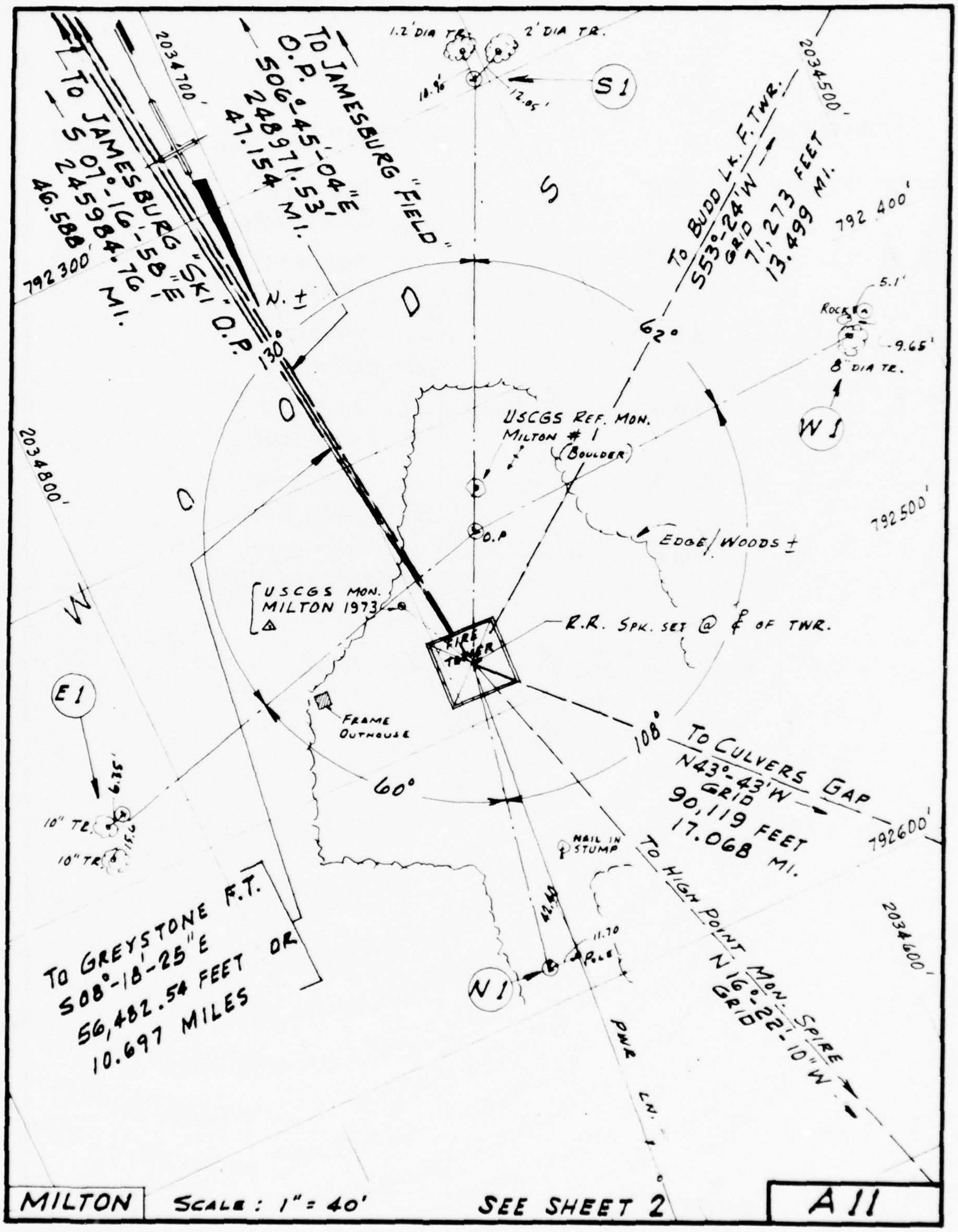
LAT. & LONG. @ ℄ OF FIRE TWR.:
40°-53'-41.8"
74°-45'-02.9"

BUDD LAKE SHEET 2 A8


CULVERS AREA
BUDD LAKE TEST AREA
TO MILTON
BUDD LAKE TEST SITE
A-9



BUDD LAKE TEST SITE, OFFSET S1



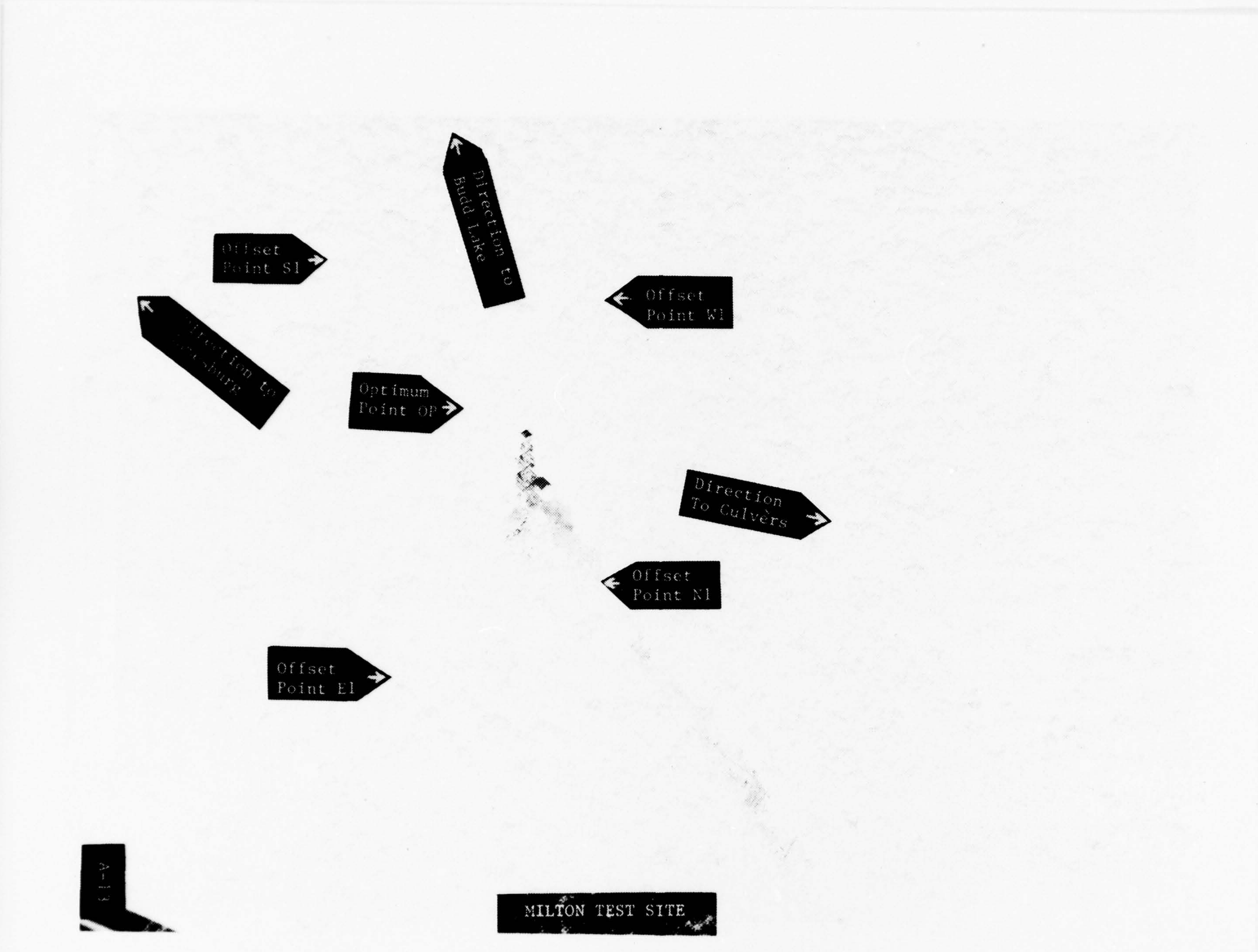
To JAMESBURG "FIELD" O.P.
S06°-45'-04"E
248971.53'
47.154 MI.
To JAMESBURG "SKI" O.P.
S 07°-16'-58"E
245984.76'
46.588 MI.
1.2' DIA TR.
2' DIA TR.
10.9'
12.05'
S1
2034700'
2034500'
To BUDD LK. F.TWR.
S53°-24'W
GRID
71,273 FEET
13.499 MI.
792 400'
792300'
N. ±
130°
62°
5.1'
ROCK
9.65'
8" DIA TR.
W1
USCGS REF. MON.
MILTON # 1
(BOULDER)
O.P
EDGE/WOODS ±
2034800'
792500'
USCGS MON.
MILTON 1973
R.R. SPK. SET @ ℄ OF TWR.
FIRE TOWER
E1
FRAME OUTHOUSE
108°
To CULVERS GAP
N43°-43'W
GRID
90,119 FEET
17.068 MI.
60°
10" TR.
10" TR.
NAIL IN STUMP
792600'
To HIGH POINT MON. SPIRE
N 16°-22'-10"W
GRID
2034600'
To GREYSTONE F.T.
S08°-18'-25"E
56,482.54 FEET OR
10.697 MILES
11.70
POLE
N1
PWR LN.
MILTON
SCALE : 1" = 40'
SEE SHEET 2
A11

ELEVATIONS		COORDINATES (N.J. PLANE)
FIRE TWR.	1365'	N. 792,480' E. 2,034,690'
O.P.	1363'	N. 792,439' E. 2,034,671'
N 1	1358'	N. 792,589' E. 2,034,712'
E 1	1354'	N. 792,477' E. 2,034,822
S 1	1359'	N. 792,298' E. 2,034,604'
W 1	1363'	N. 792,427' E. 2,034,516'

LAT. & LONG. @ ℄ OF FIRE TWR.:
41°-00'-31.8"
74°-32'-27.8

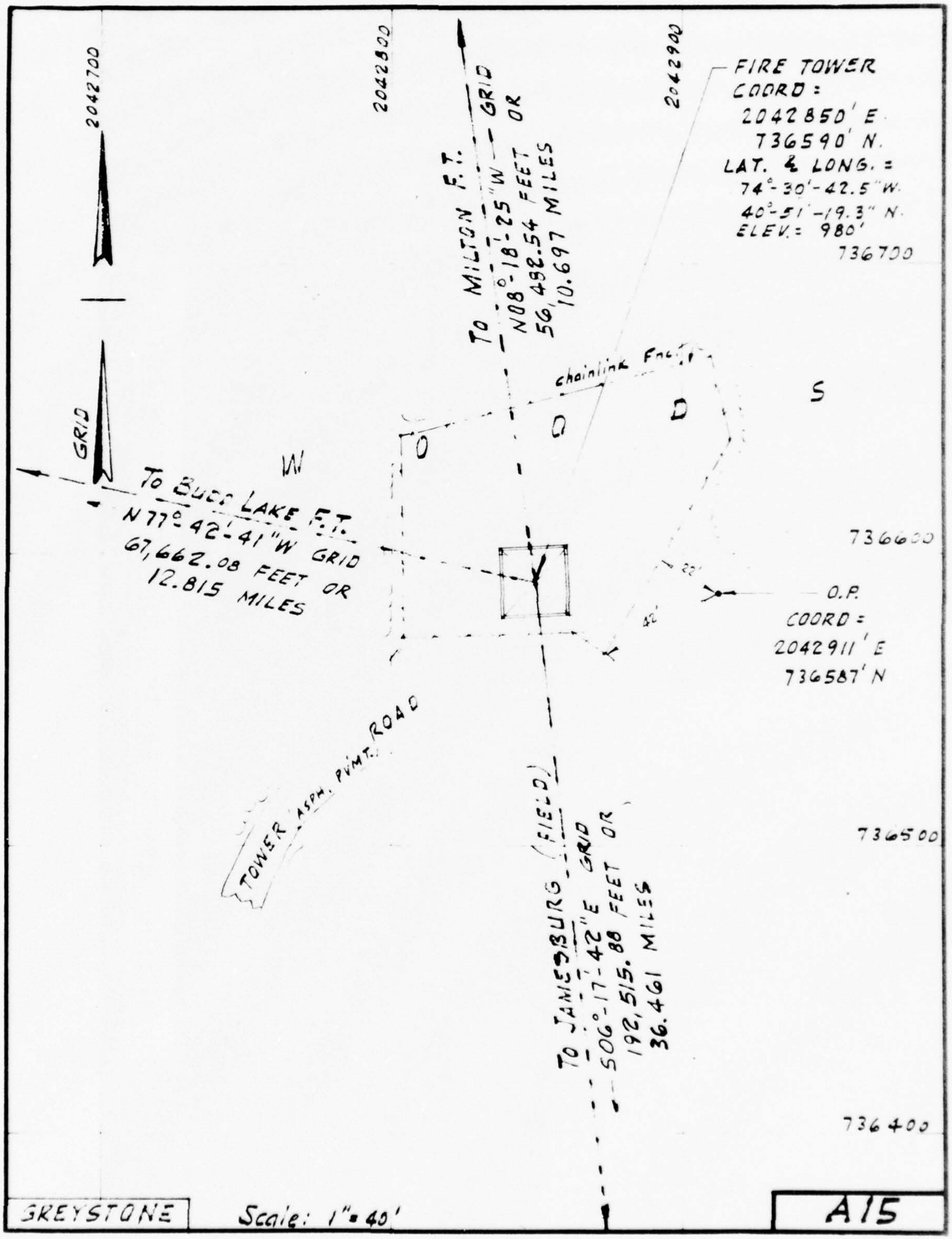
MILTON SHEET 2

A12

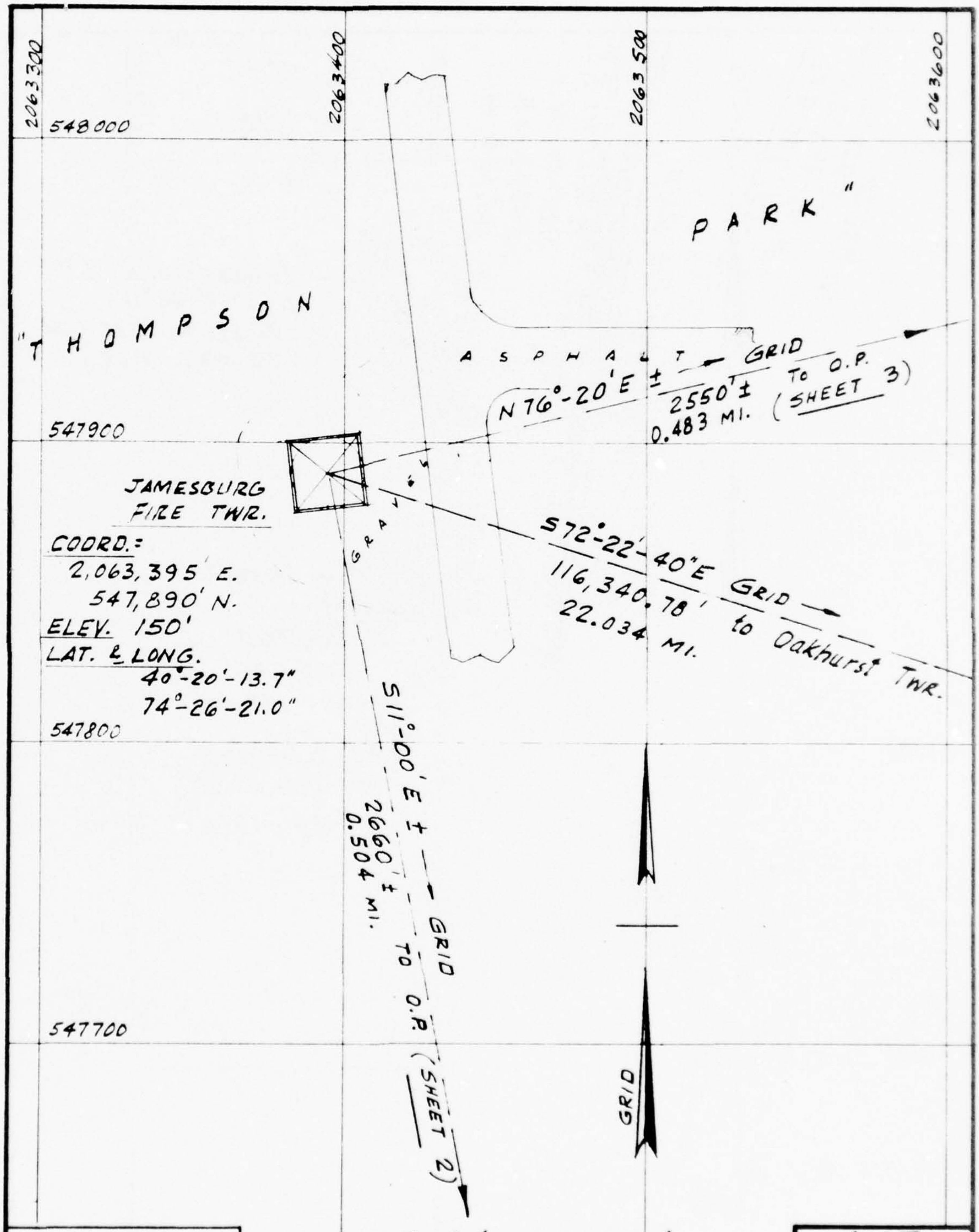


MILTON TEST SITE

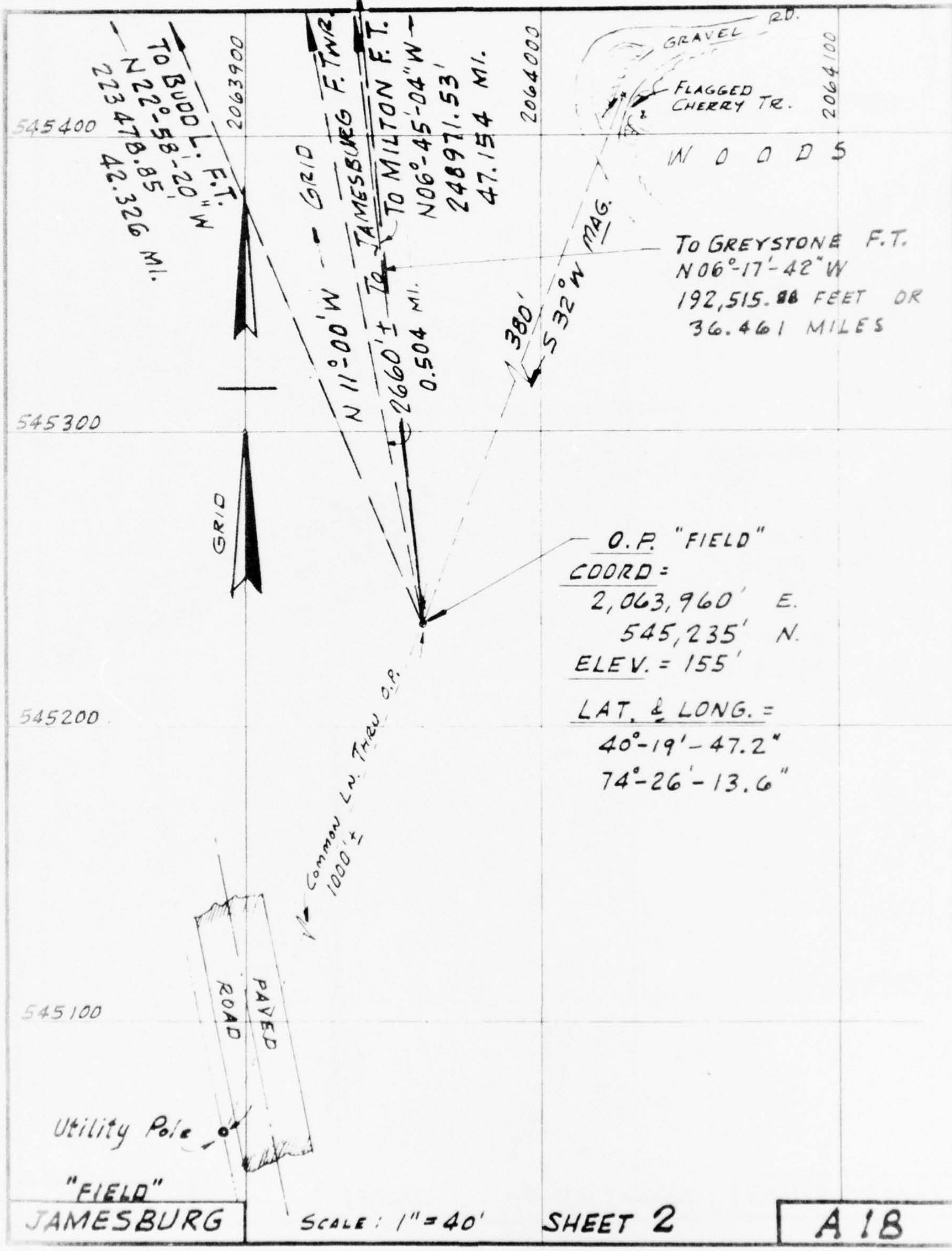
MILTON TEST SITE, OFFSET S.5


FIRE TOWER
COORD =
2042850' E
736590' N.
LAT. & LONG. =
74°-30'-42.5" W.
40°-51'-19.3" N.
ELEV. = 980'
2042700
2042800
2042900
736700
736600
736500
736400
GRID
To MILTON F.T.
N08°-18'-25"W — GRID
56,498.54 FEET OR
10.697 MILES
chainlink Fnc.
W
O
O
D
S
To BUCC LAKE F.T.
N77°-42'-41"W GRID
67,662.08 FEET OR
12.815 MILES
O.P.
COORD =
2042911' E
736587' N
TOWER ASPH. PVMT. ROAD
To JAMESBURG (FIELD)
S06°-17'-42"E GRID
192,515.88 FEET OR
36.461 MILES
GREYSTONE
Scale: 1" = 40'
A15

VIEW FROM GREYSTONE OP, LOOKING SOUTH TOWARDS JAMESBURG



JAMESBURG	SCALE: 1" = 40'	SHEET 1	A17

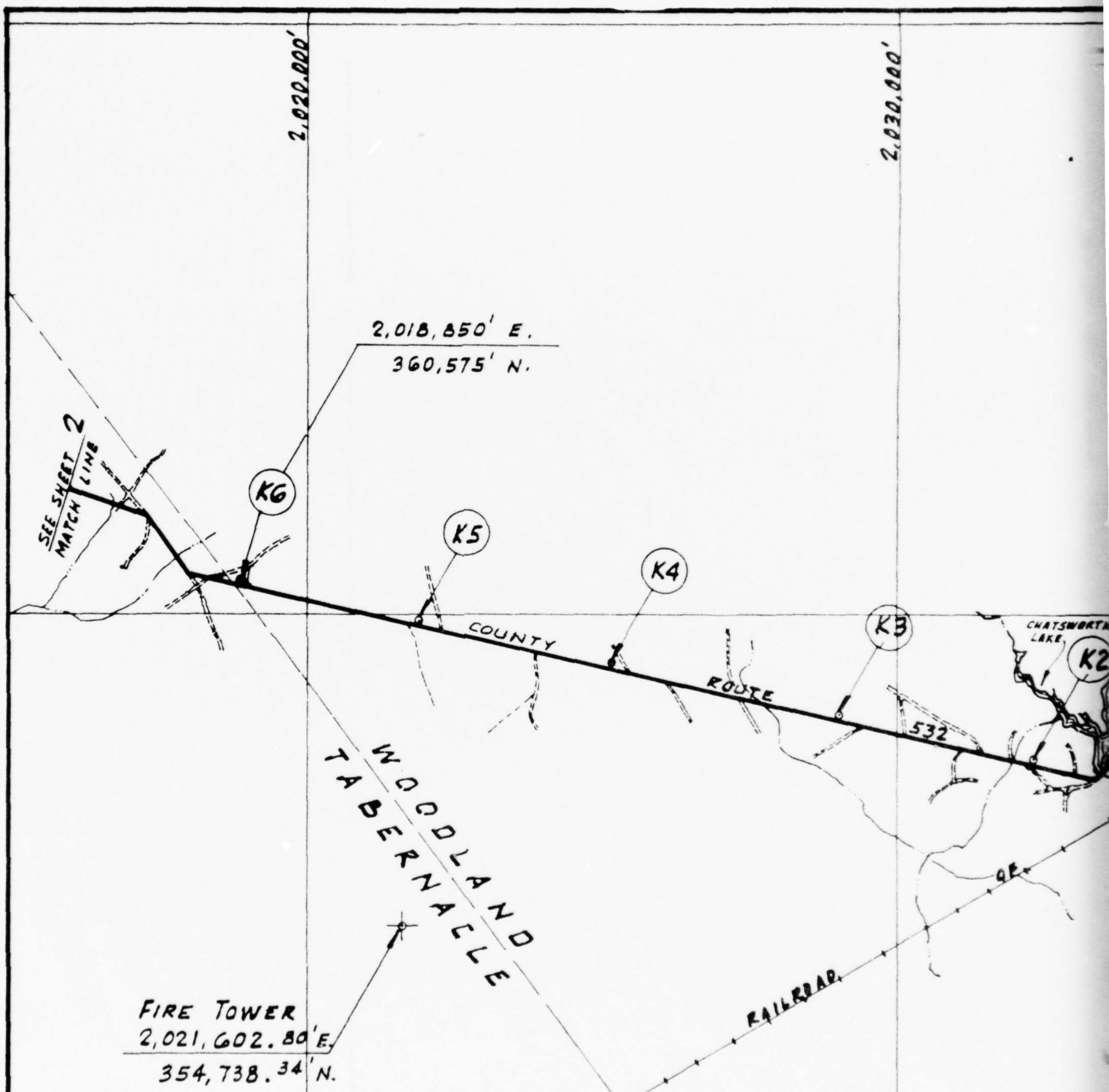


To BUDD L. F.T.
N 22°-58'-20" W
223478.85'
42.326 MI.
2063900
GRID
N 11°-00' W - GRID
To JAMESBURG F.TWR.
2660' ± To
0.504 MI.
To MILTON F.T.
N06°-45'-04" W
248971.53'
47.154 MI.
2064000
GRAVEL RD.
FLAGGED CHERRY TR.
2064100
WOODS
380'
S 32° W MAG.
To GREYSTONE F.T.
N 06°-17'-42" W
192,515.88 FEET OR
36.461 MILES
545400
545300
545200
545100
O.P. "FIELD"
COORD =
2,063,960' E.
545,235' N.
ELEV. = 155'
LAT. & LONG. =
40°-19'-47.2"
74°-26'-13.6"
COMMON LN. THRU O.P.
1000' ±
PAVED ROAD
Utility Pole
"FIELD"
JAMESBURG
SCALE: 1" = 40'
SHEET 2
A 18

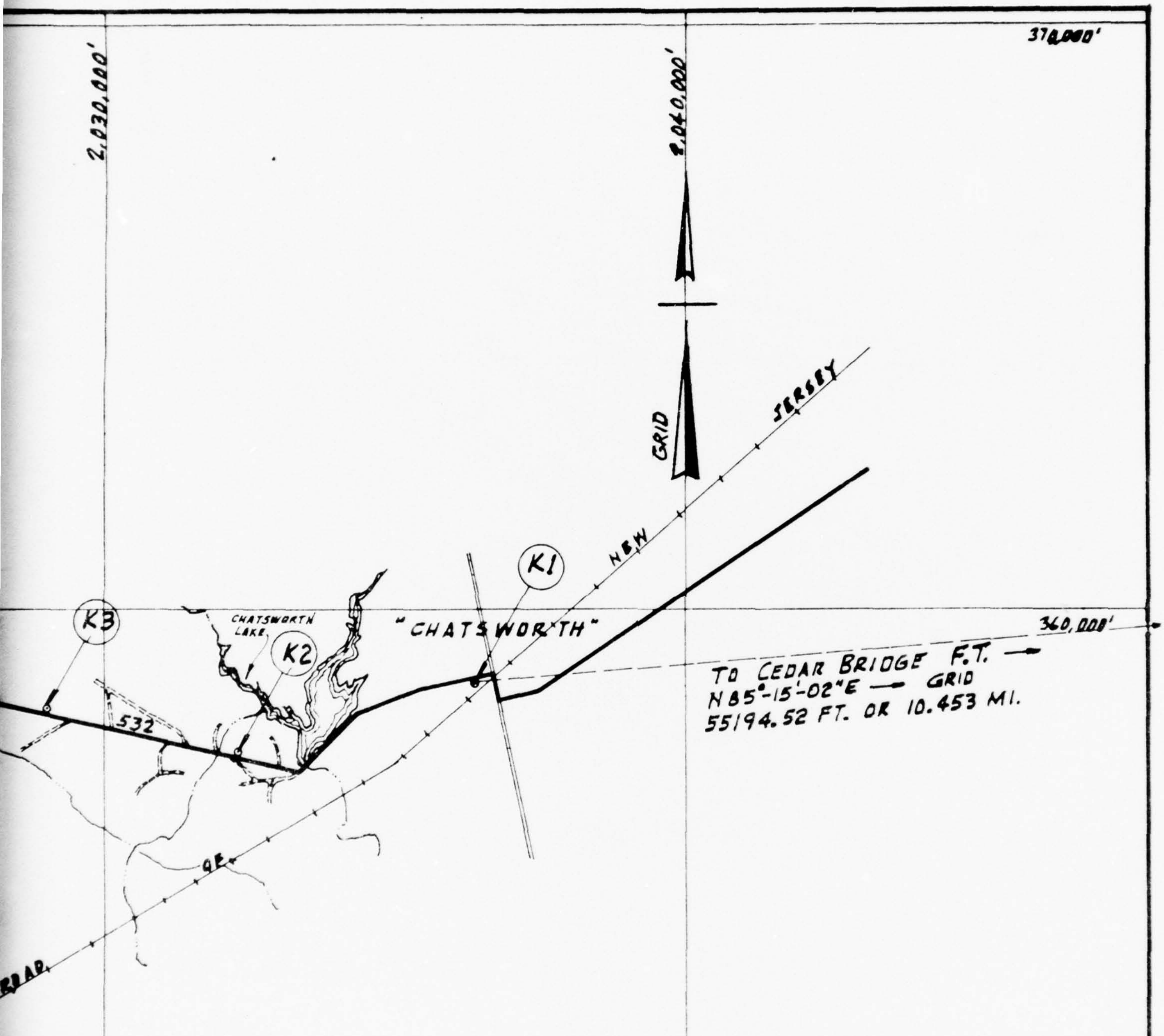

DIRECTION TO
FIRE TOWER
OPTIMUN
JAMESBURG TEST SITE

APPENDIX B

FLAT TERRAIN TEST SITE INFORMATION

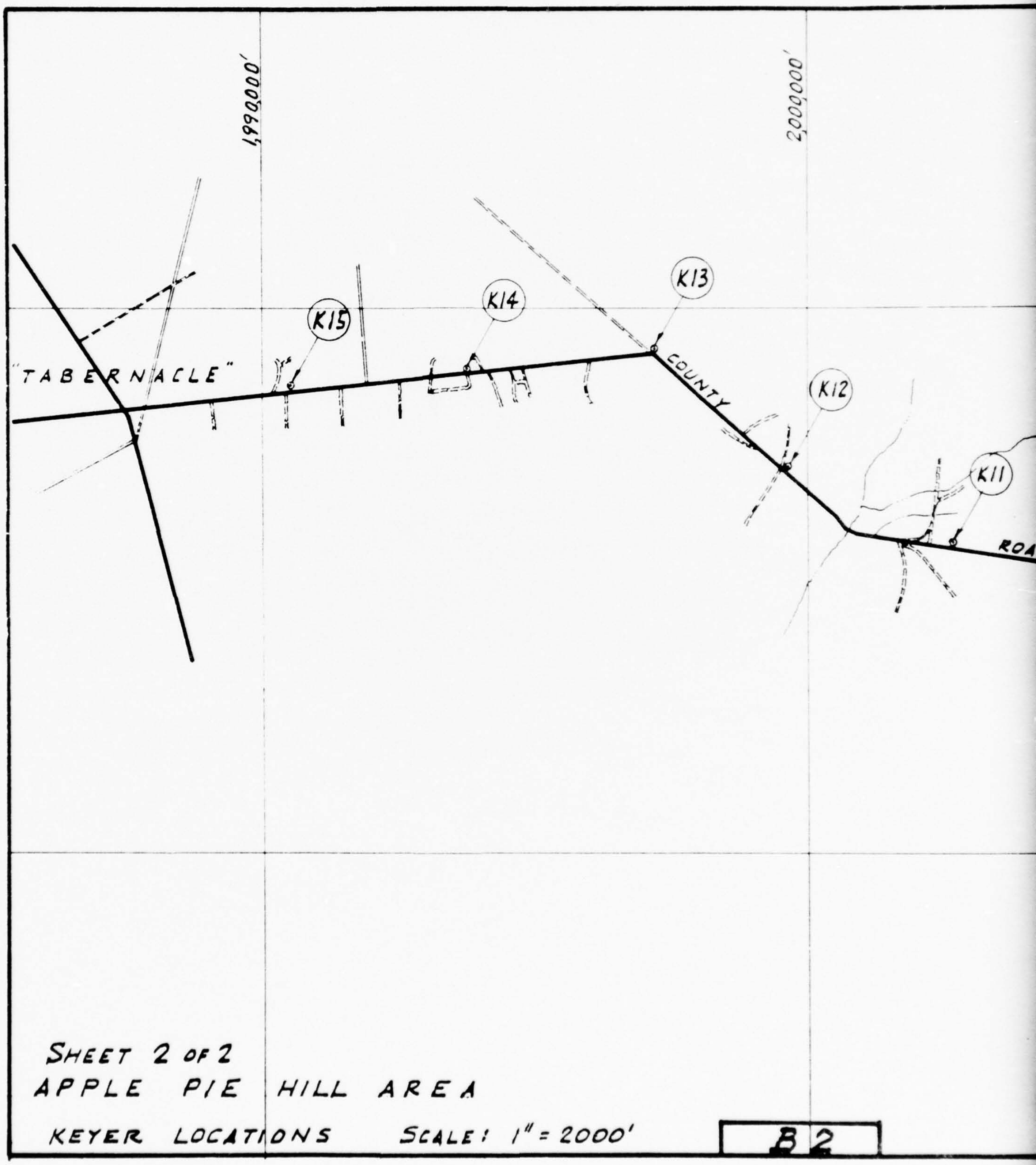


2,020,000'
2,030,000'
2,018,850' E.
360,575' N.
SEE SHEET 2
MATCH LINE
K6
K5
K4
K3
K2
COUNTY
ROUTE
532
CHATSWORTH LAKE
WOODLAND
TABERNACLE
FIRE TOWER
2,021,602.80'E.
354,738.34'N.
RAILROAD
CENTRAL
SHEET 1 OF 2
APPLE PIE HILL AREA
KEYER LOCATIONS
SCALE: 1"=2000'
B1

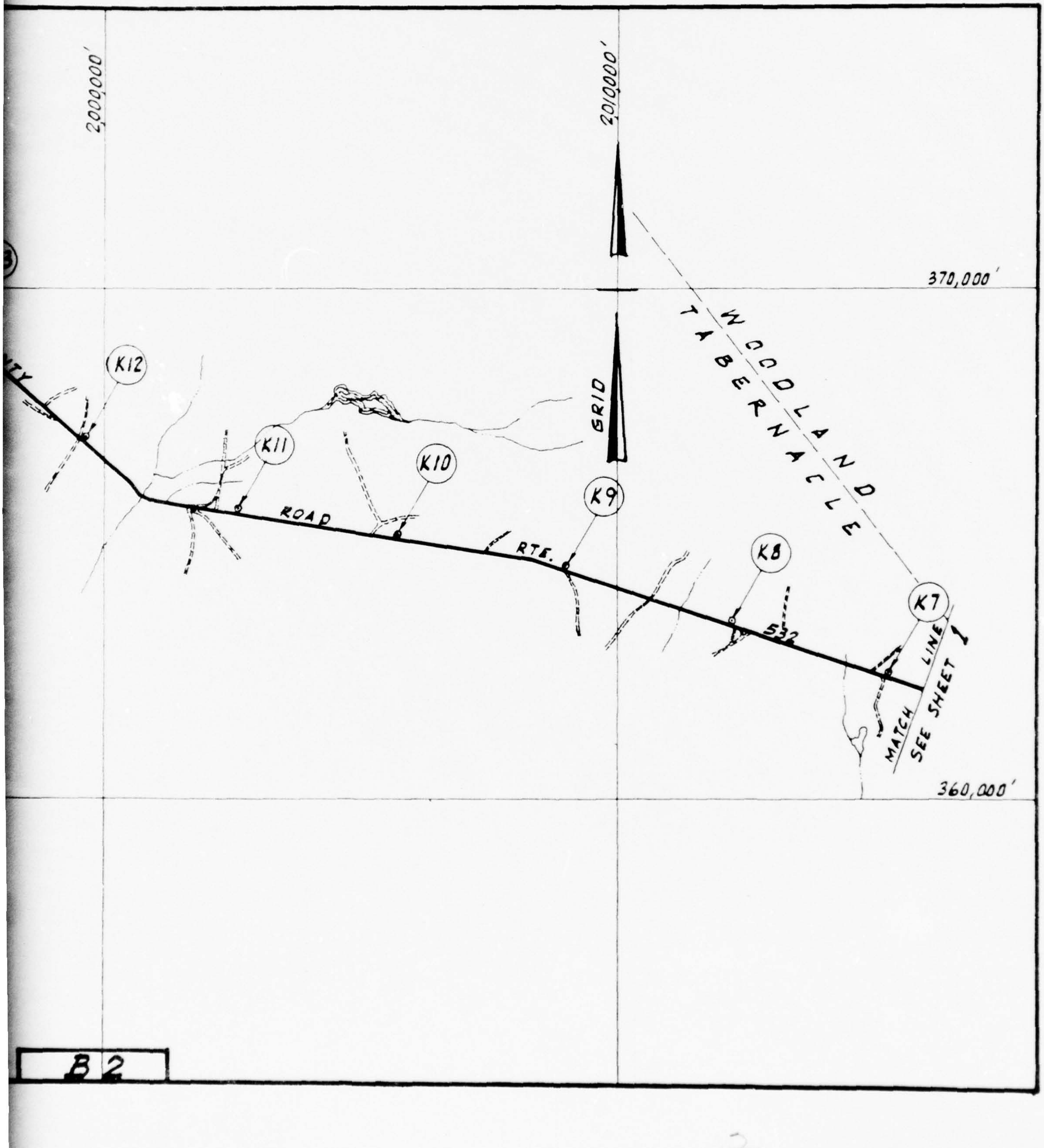


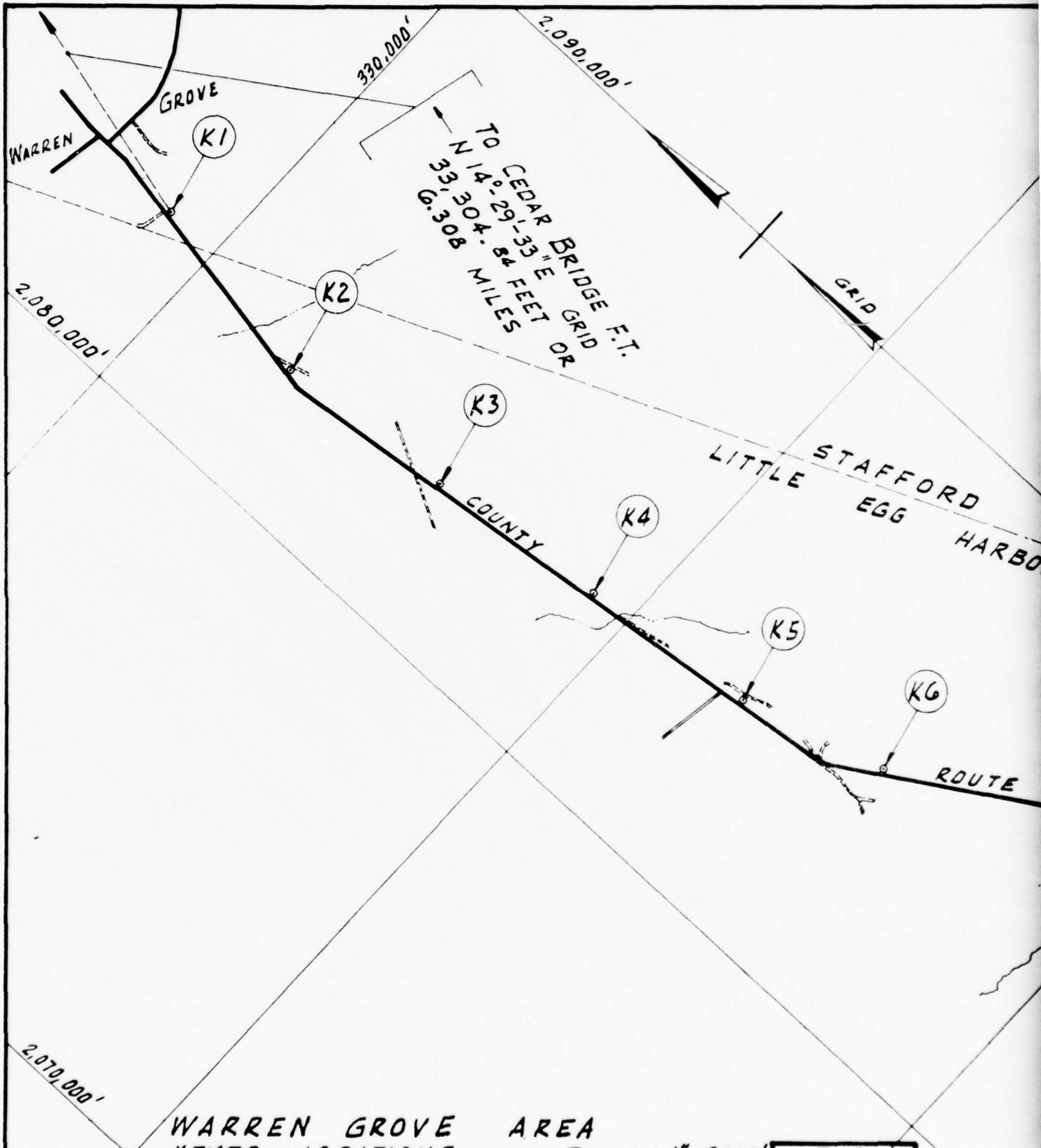
2,030,000'
2,040,000'
370,000'
360,000'
350,000'
GRID
NEW JERSEY
ROAD
K1
K2
K3
CHATSWORTH LAKE
"CHATSWORTH"
532
TO CEDAR BRIDGE F.T.
N85°-15'-02"E GRID
55194.52 FT. OR 10.453 MI.
B1

2



1,990,000'
2,000,000'
K15
K14
K13
K12
K11
"TABERNACLE"
COUNTY
ROA
SHEET 2 OF 2
APPLE PIE HILL AREA
KEYER LOCATIONS
SCALE: 1" = 2000'
B 2

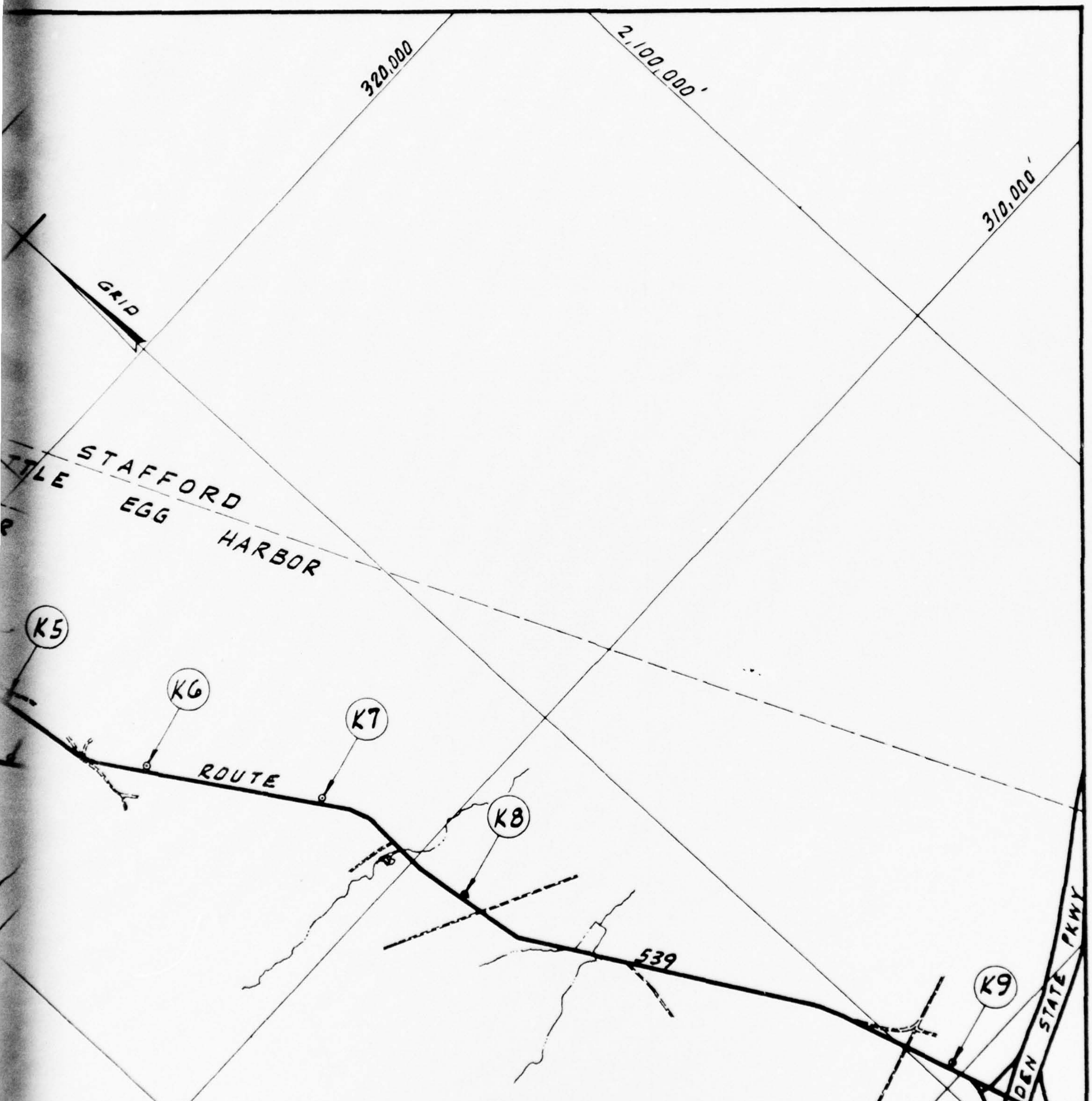

2,000,000'
2,010,000'
370,000'
360,000'
GRID
WOODLAND
TABERNACLE
K12
K11
K10
K9
K8
K7
ROAD
RTE.
532
MATCH LINE
SEE SHEET 1
B 2



WARREN GROVE AREA
KEYER LOCATIONS

SCALE: 1"=2000'

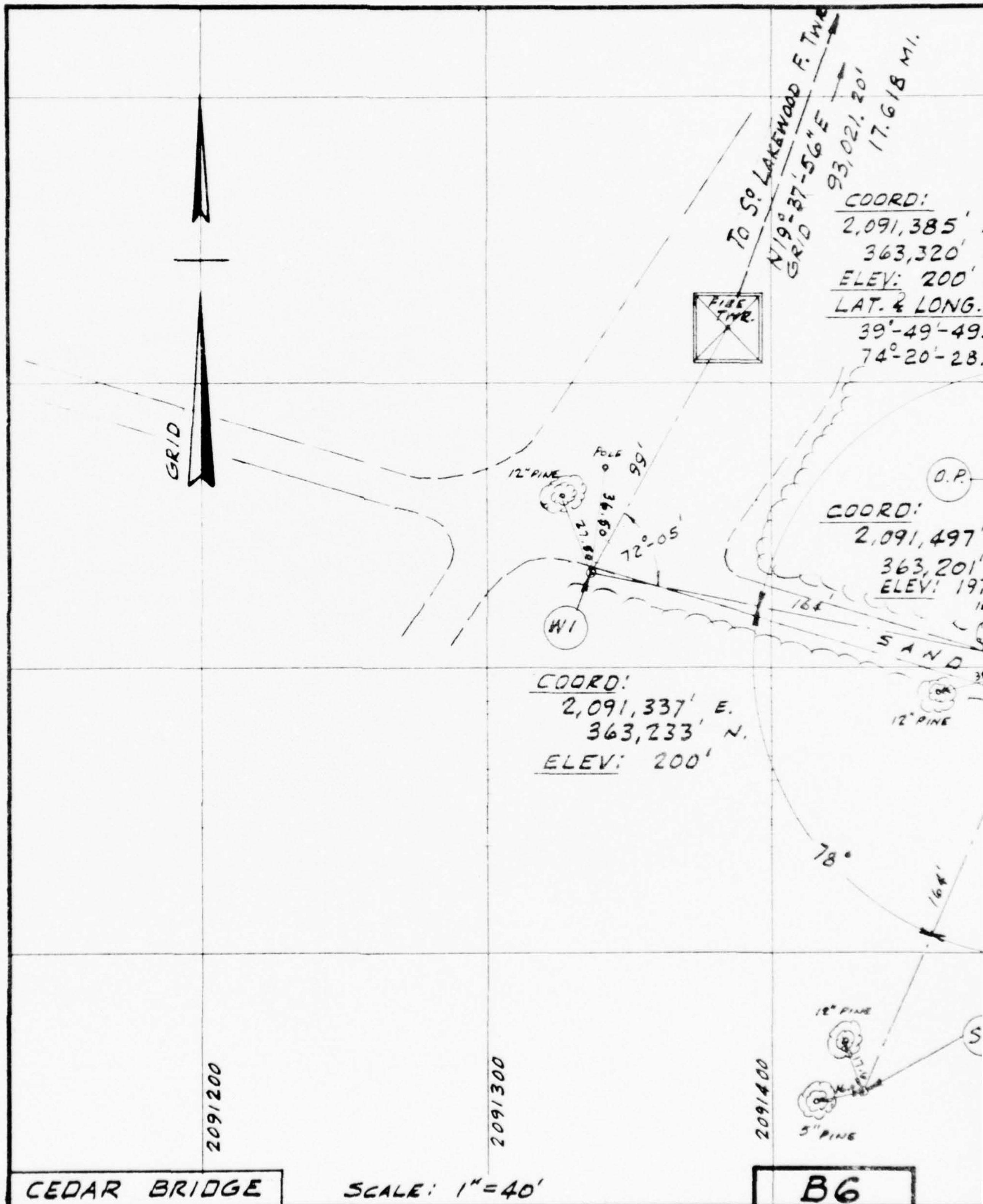
B3



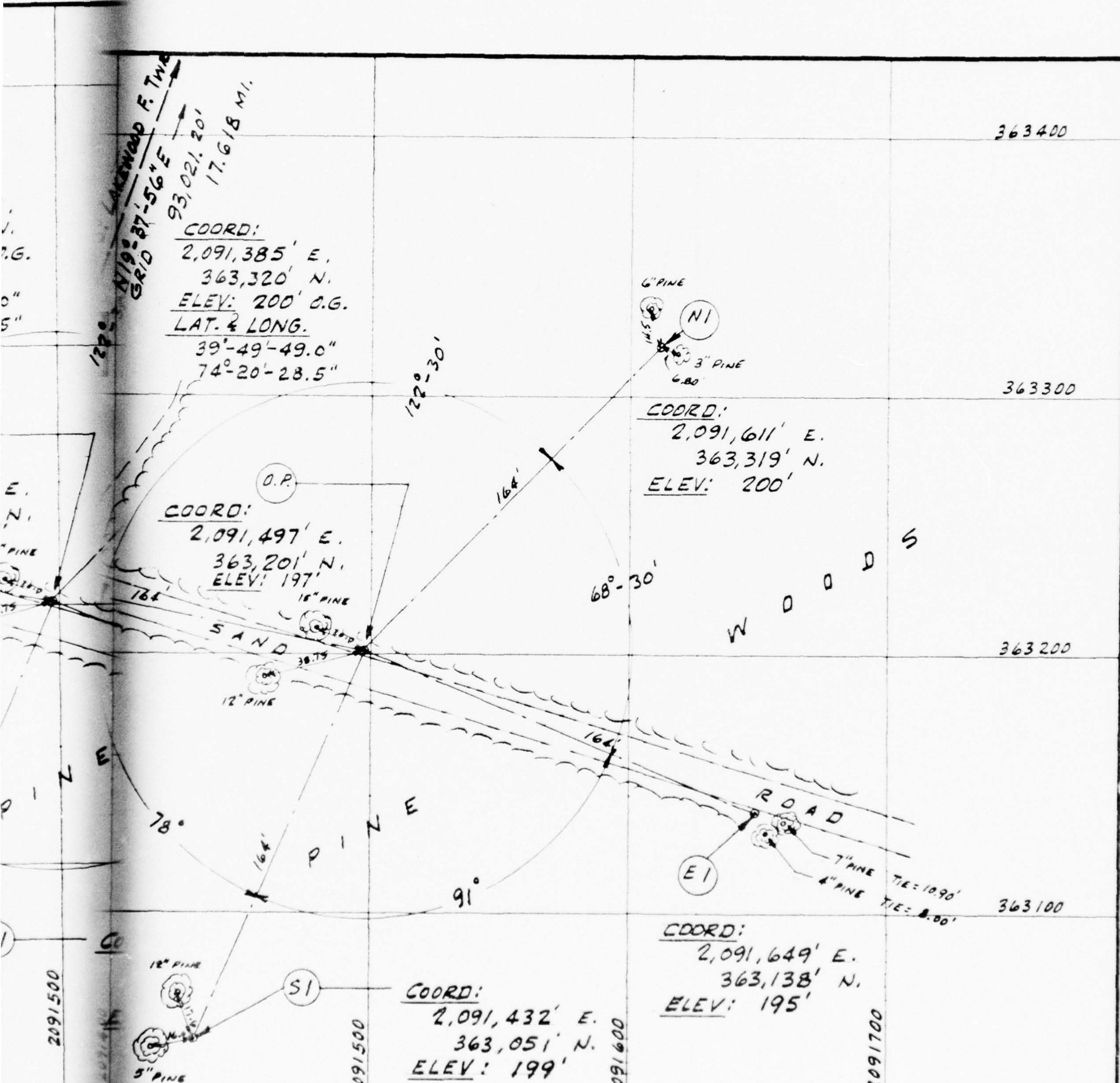
320,000
2,100,000'
310,000'
GRID
STAFFORD
TLE EGG HARBOR
K5
K6
K7
K8
K9
ROUTE
539
GARDEN STATE PKWY
B3

2

APPLE PIE AREA K9

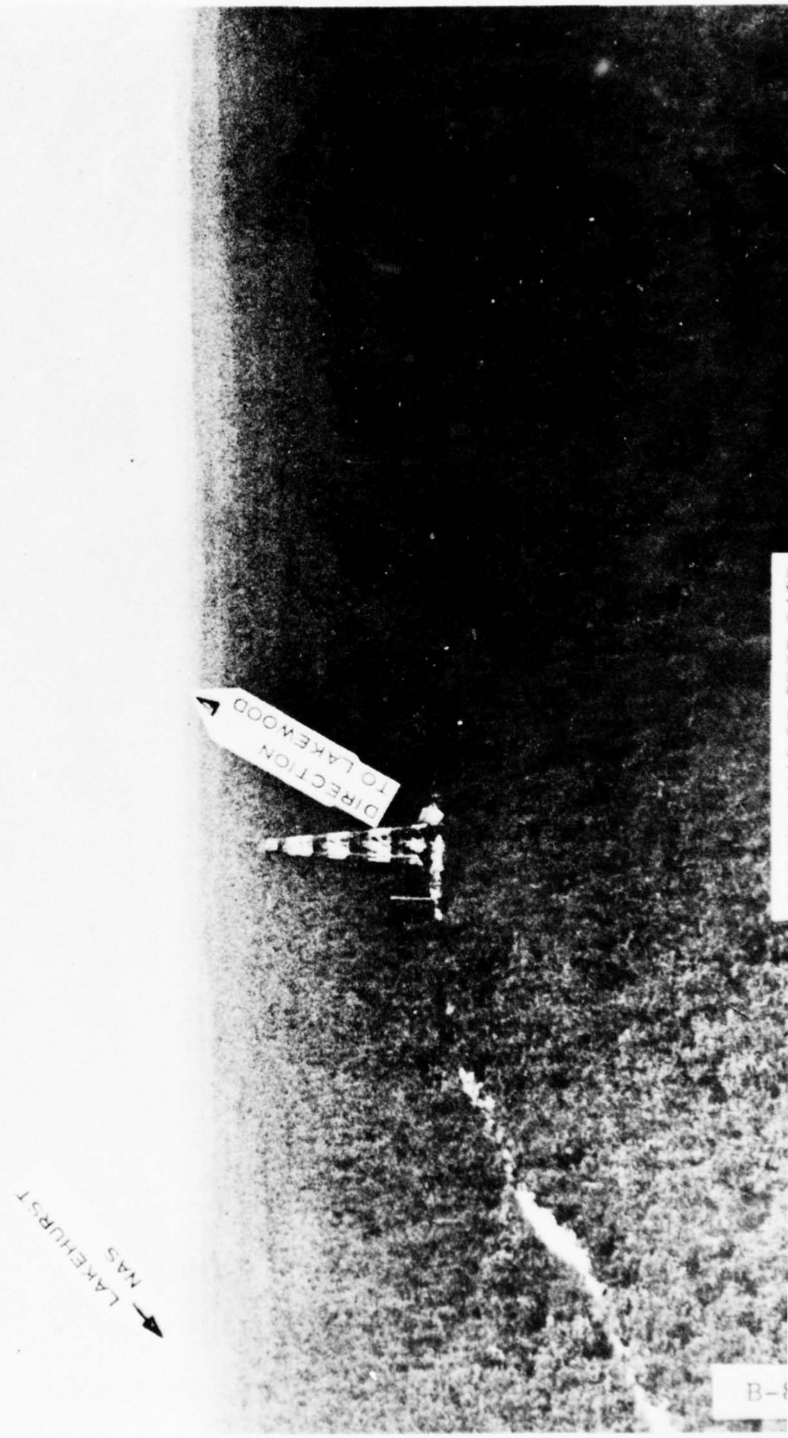


TO So LAKEWOOD F. TWR
N 19°-37'-56" E
GRID
93,021.20'
17.618 MI.
COORD:
2,091,385'
363,320'
ELEV: 200'
LAT. & LONG.
FIRE TWR.
GRID
POLE
12" PINE
99'
72°-05'
W1
COORD:
2,091,337' E.
363,233' N.
ELEV: 200'
O.P.
COORD:
2,091,497'
363,201'
SAND
12" PINE
78°
16'
12" PINE
5" PINE
2091200
2091300
2091400
CEDAR BRIDGE
SCALE: 1"=40'
B6

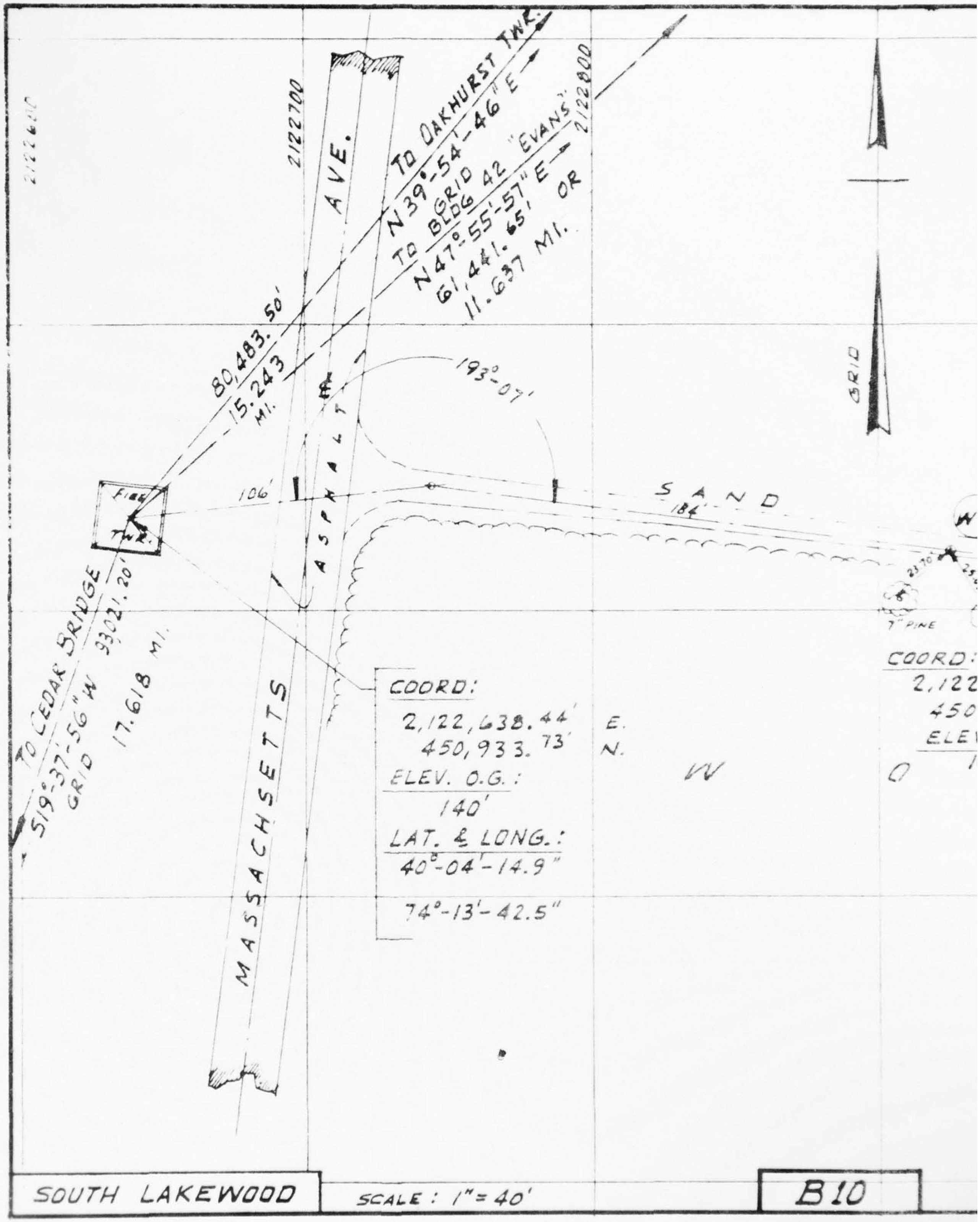


LAKEWOOD F. TWR
N 19°-37'-56" E
GRID
93,021.20'
17.618 MI.
122°
COORD:
2,091,385' E.
363,320' N.
ELEV: 200' O.G.
LAT. & LONG.
39°-49'-49.0"
74°-20'-28.5"
122°-30'
6" PINE
N1
3" PINE
COORD:
2,091,611' E.
363,319' N.
ELEV: 200'
164'
O.P.
COORD:
2,091,497' E.
363,201' N.
ELEV: 197'
68°-30'
W O O D S
16" PINE
SAND
ROAD
12" PINE
164'
PINE
78°
164'
91°
E1
7" PINE TIE = 10.90'
4" PINE TIE = 8.00'
COORD:
2,091,649' E.
363,138' N.
ELEV: 195'
12" PINE
S1
5" PINE
COORD:
2,091,432' E.
363,051' N.
ELEV: 199'
363400
363300
363200
363100
2091500
2091500
2091600
2091700
B6

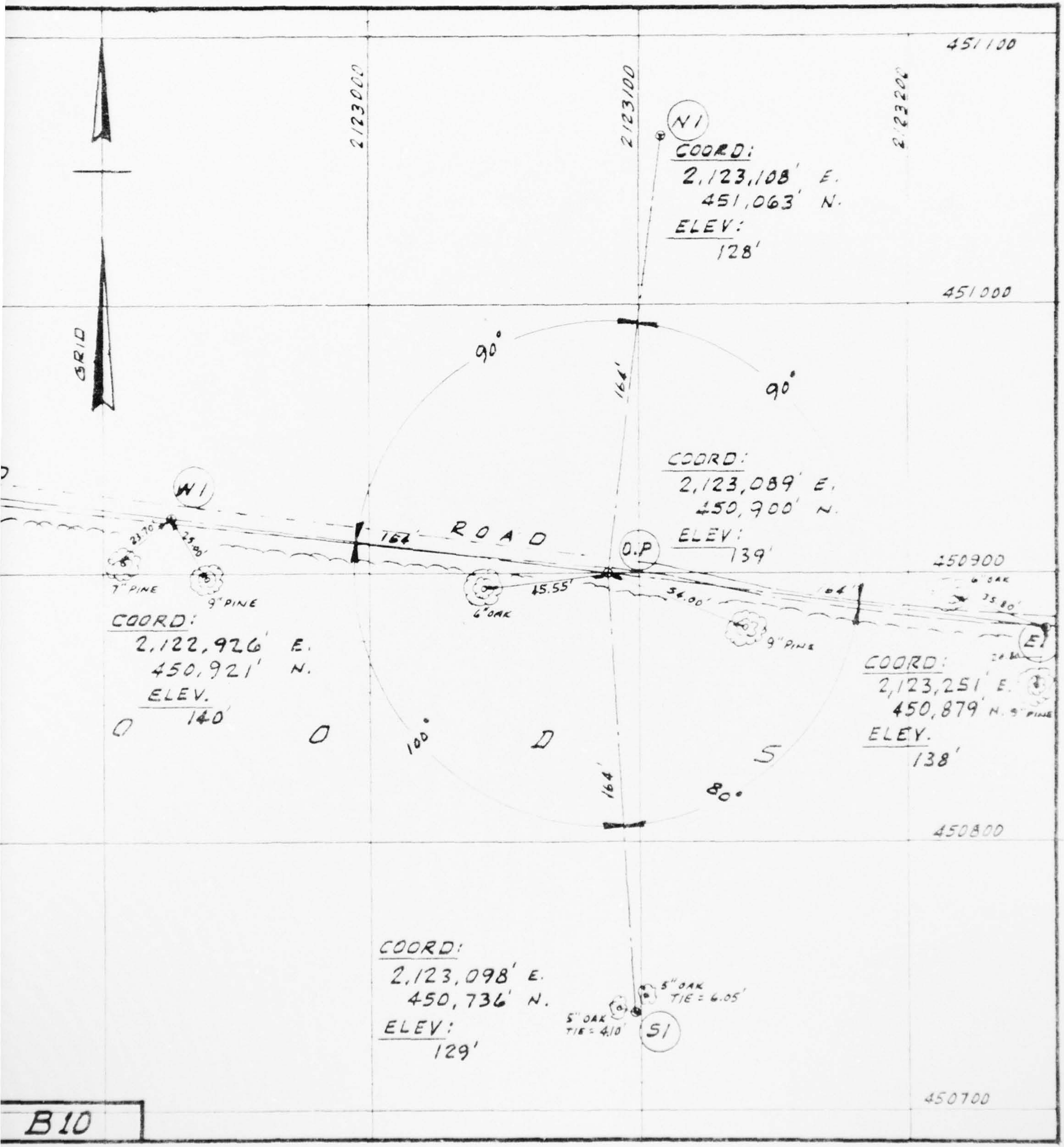

CEDER BRIDGE TEST SITE
B-


DIRECTION TO LAKEWOOD
LAKEHURST NAS

B-



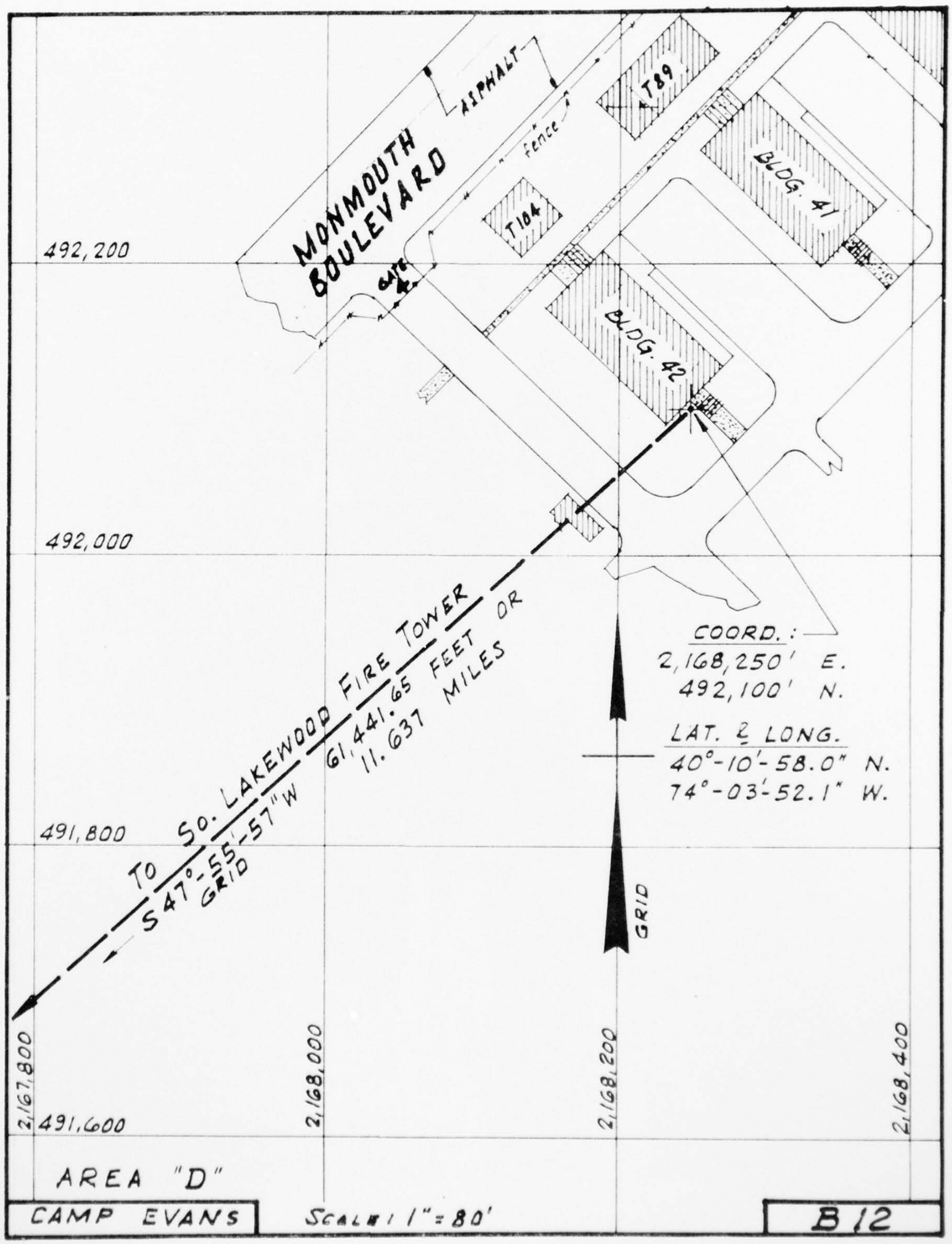
TO OAKHURST TWR.
N39°-54'-46"E
80,483.50'
15.243 MI.
TO GRID "EVANS" BLDG 42
N47°-55'-57"E
61,441.65' OR
11.637 MI.
2122700
2122800
AVE.
MASSACHSETTS
ASPHALT
℄
193°-07'
106'
SAND
184'
FIRE TWR.
TO CEDAR BRIDGE
S19°-37'-56"W 93021.20'
GRID 17.618 MI.
COORD:
2,122,638.44' E.
450,933.73' N.
ELEV. O.G.:
140'
LAT. & LONG.:
40°-04'-14.9"
74°-13'-42.5"
W
O
GRID
7" PINE
SOUTH LAKEWOOD
SCALE: 1"= 40'
B10



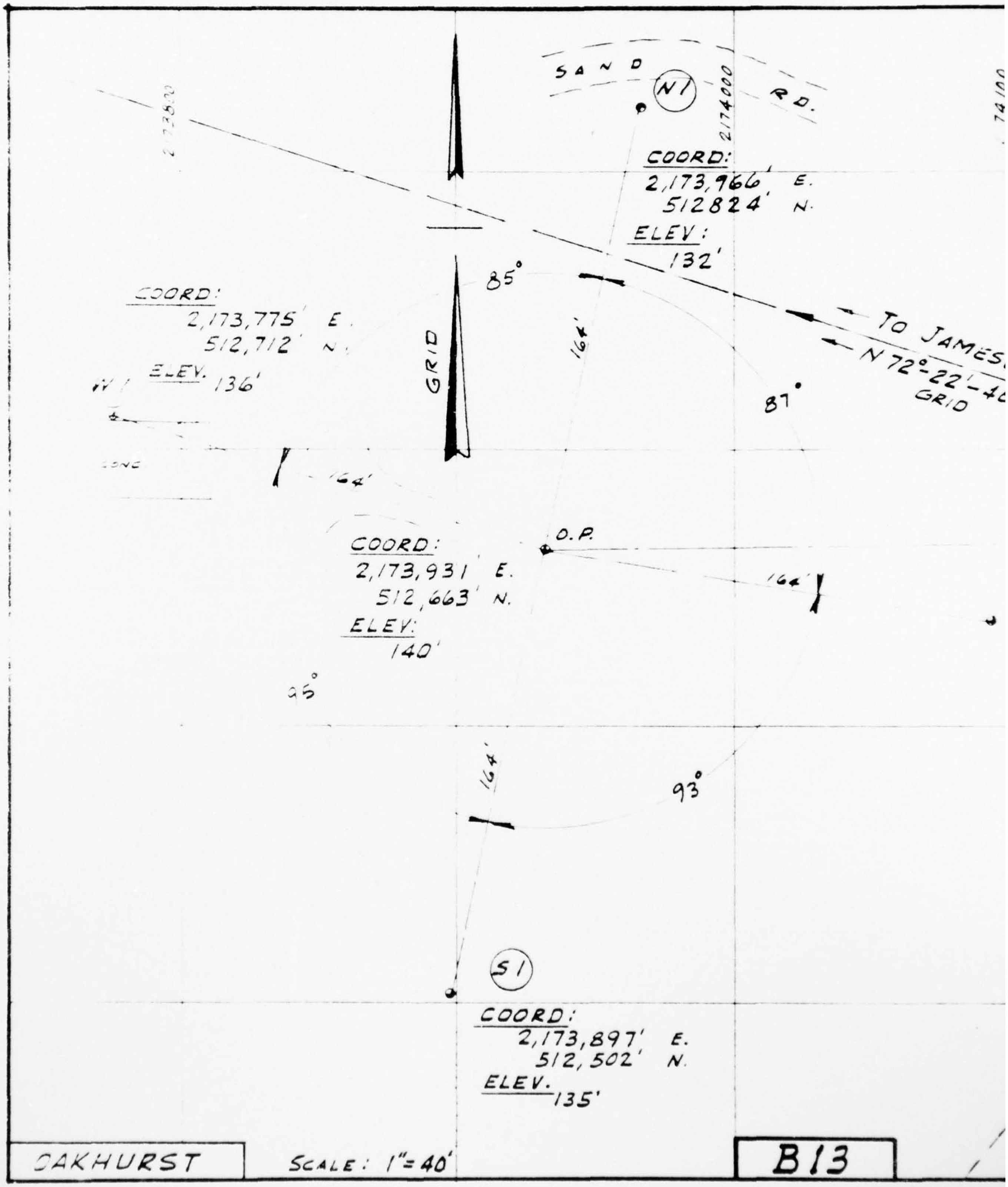
451100
2123000
2123100
2123200
N1
COORD:
2,123,108' E.
451,063' N.
ELEV:
128'
GRID
451000
90°
90°
164'
COORD:
2,123,089' E.
450,900' N.
ELEV:
139'
W1
ROAD
O.P
164'
450900
7" PINE
9" PINE
6" OAK
15.55'
34.00'
164'
6" OAK
9" PINE
E1
COORD:
2,122,926' E.
450,921' N.
ELEV.
140'
COORD:
2,123,251' E.
450,879' N.
ELEV.
138'
9" PINE
O
O
100°
D
S
164'
80°
450800
COORD:
2,123,098' E.
450,736' N.
ELEV:
129'
5" OAK
TIE = 6.05'
5" OAK
TIE = 4.10'
S1
450700
B10

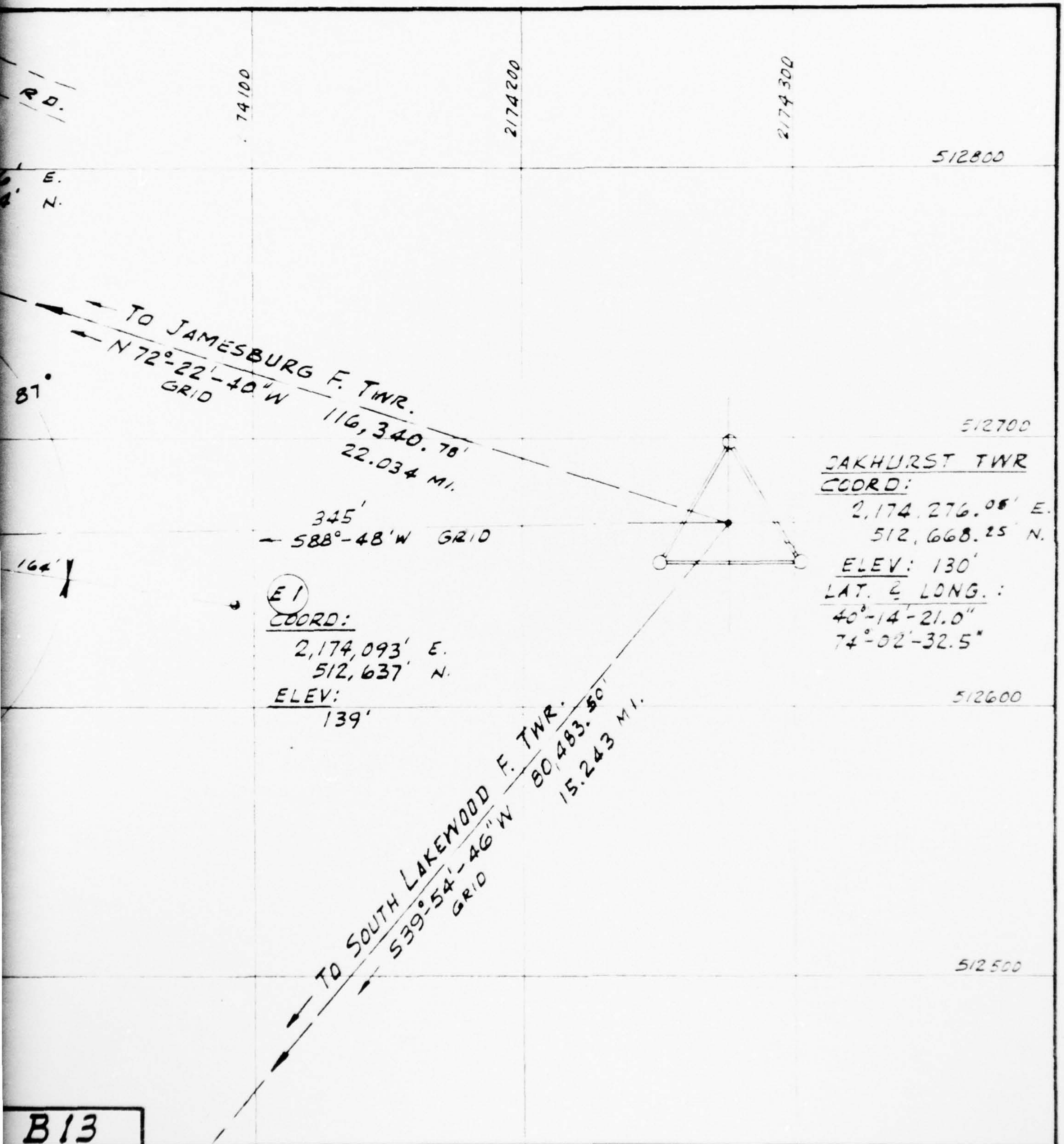
2


DIRECTION
TO OAKHURST
OFF-SET
POINT NI
OFF-SET
POINT WI
OPTIMUN
POINT OP
OFF-SET
POINT EI
OFF SET
POINT SI
LAKEWOOD TEST SITE
D-11

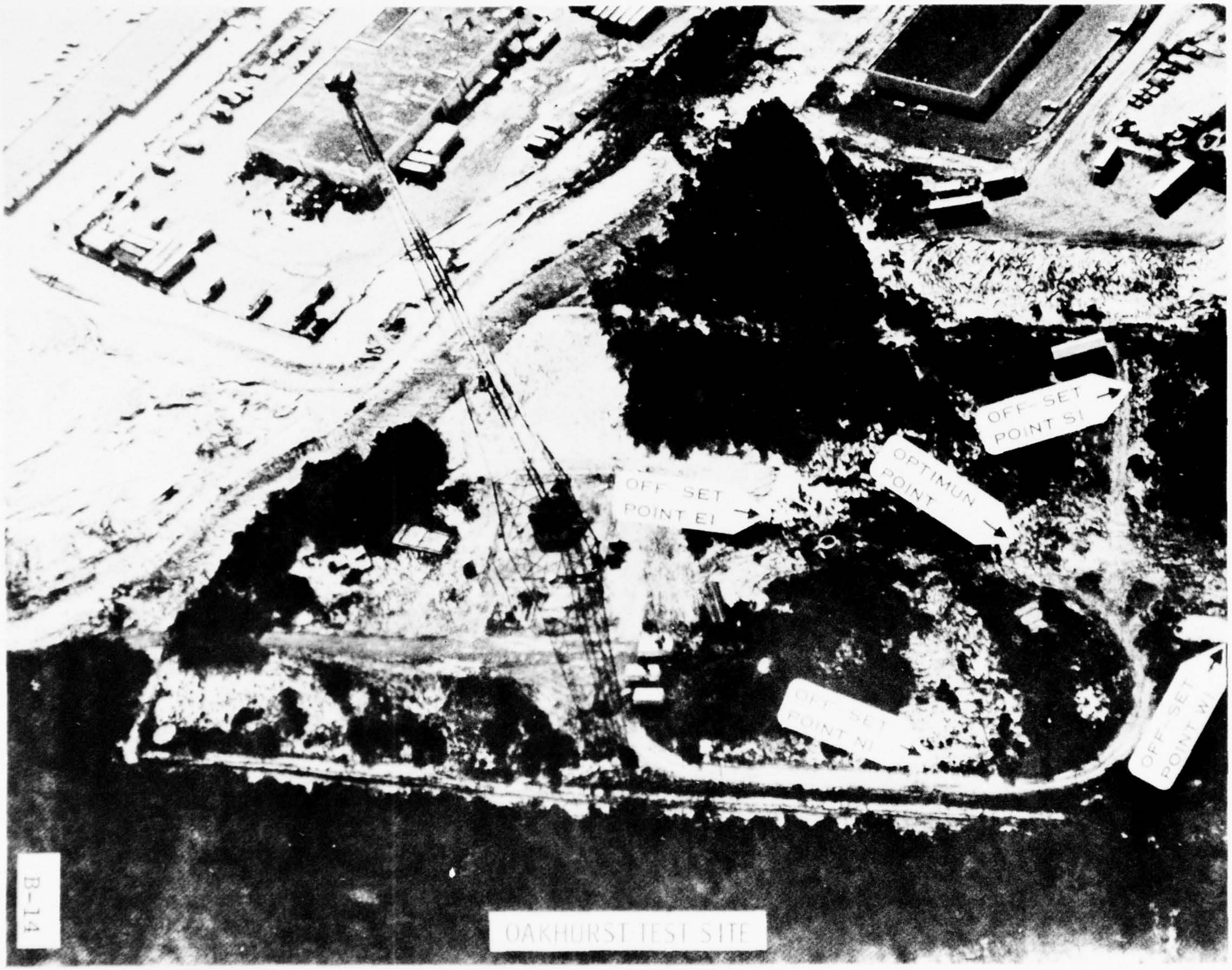


ASPHALT
T89
fence
MONMOUTH BOULEVARD
BLDG. 41
T104
GATE 4
BLDG. 42
492,200
492,000
491,800
491,600
COORD.:
2,168,250' E.
492,100' N.
LAT. & LONG.
40°-10'-58.0" N.
74°-03'-52.1" W.
TO So. LAKEWOOD FIRE TOWER
S 47°-55'-57" W GRID
61,441.65 FEET OR
11.637 MILES
GRID
2,167,800
2,168,000
2,168,200
2,168,400
AREA "D"
CAMP EVANS
SCALE: 1" = 80'
B 12


SAND RD.
N1
2174000
2173800
74100
COORD:
2,173,966' E.
512824' N.
ELEV:
132'
85°
164'
COORD:
2,173,775' E.
512,712' N.
ELEV. 136'
GRID
TO JAMES
N 72°-22'-4
GRID
87°
164'
O.P.
COORD:
2,173,931' E.
512,663' N.
ELEV:
140'
164'
95°
164'
93°
S1
COORD:
2,173,897' E.
512,502' N.
ELEV.
135'
OAKHURST
SCALE: 1"=40'
B13



RD.
74100
2174200
2174300
512800
E.
N.
TO JAMESBURG F. TWR.
N 72°-22'-40"W
GRID
116,340.78'
22.034 MI.
87°
512700
OAKHURST TWR
COORD:
2,174,276.08' E.
512,668.25 N.
ELEV: 130'
LAT. & LONG.:
40°-14'-21.0"
74°-02'-32.5"
345'
S88°-48'W GRID
164'
E1
COORD:
2,174,093' E.
512,637' N.
ELEV:
139'
512600
TO SOUTH LAKEWOOD F. TWR.
S39°-54'-46"W
GRID
80,483.50'
15.243 MI.
512500
B13


OFF-SET POINT S1
OPTIMUN POINT
OFF-SET POINT E1
OFF-SET POINT N1
OFF-SET POINT W1
OAKHURST TEST SITE

OAKHURST TEST SITE "OP" - 30 FOOT SPIKE ANTENNA

APPENDIX C

Flat and Hilly Terrain Test Area Link Profiles and Degree of RF Shielding Charts

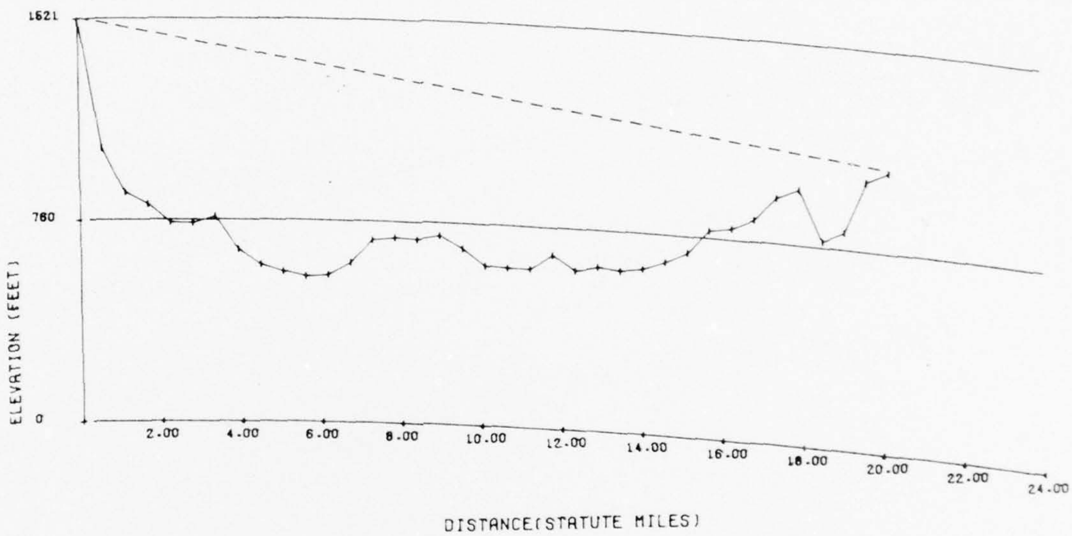
The chart and profiles contained in this Appendix were prepared as a result of a program conducted by the Electromagnetic Compatibility Analysis Center (ECAC) for the CS&TA Laboratory. The degree of RF shielding chart is a two dimension overlay which is placed on a standard topographic map which displays the RF line-of-sight (LOS) for a 30 foot receive antenna located in the Cedar Bridge monitor site area. A one (1) on the chart means if the receive antenna is raised an additional ten (10) feet, all points depicted by a one (1) will fall within the LOS area. Two's (2) indicate that the areas shown as two's will become LOS if the receive antenna is raised an additional twenty (20) feet. The same relationship applies to each succeeding magnitude of digits. Numbers greater than 9 are depicted by an asterisk (*) which means the receive antenna must be raised at least an additional 100 feet to provide LOS within the subject areas. A similar chart for the Culvers/Dingman's Ferry Area is available upon request.

ECAC also provided terrain profiles (4/3 Earth) which represented the RF propagation paths for each repeater link utilized in the hilly and flat terrain areas. Two (2) profiles per link are shown, one for 10 foot transmit and receive antennas and the other for 30 foot antenna heights. These portray the poorest and best cases respectively. In addition, ECAC performed a signal path-loss study for the subject links. Copies are available upon request.

The ECAC study results are valuable in that direct correlation can be made between the LOS status of a propagation path and the actual link reliability found during the field tests.

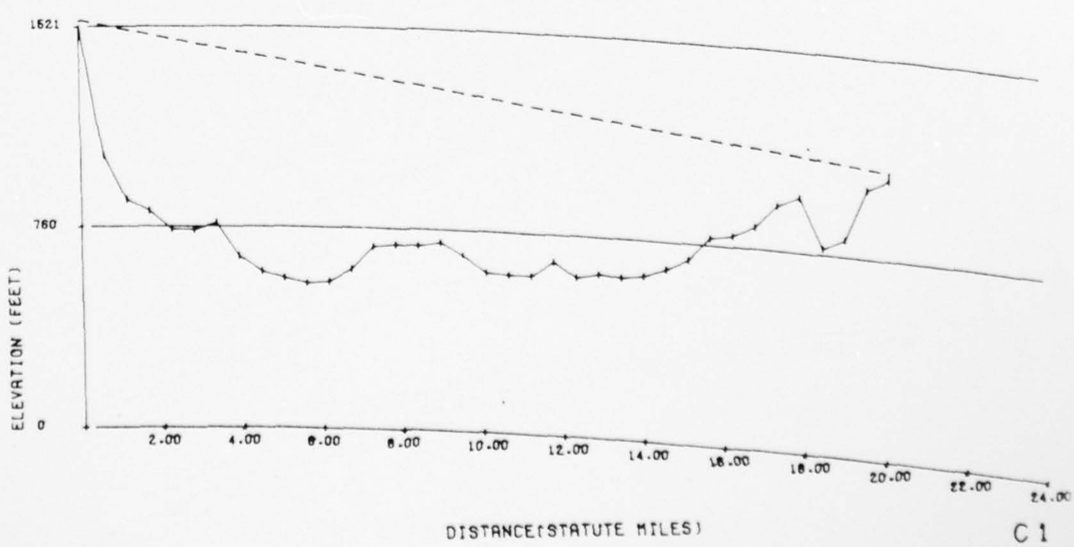
CULVERS GAP-BUDD LAKE
TERRAIN PROFILE - 4/3 EARTH

TX LAT= 41-11-15 N TX LON=74-48-0 W RX LAT=40-53-42 N RX LON=74-45-3 W
TX ELEV= 1515.00 FT RX ELEV= 1066.80 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 10.00 FT



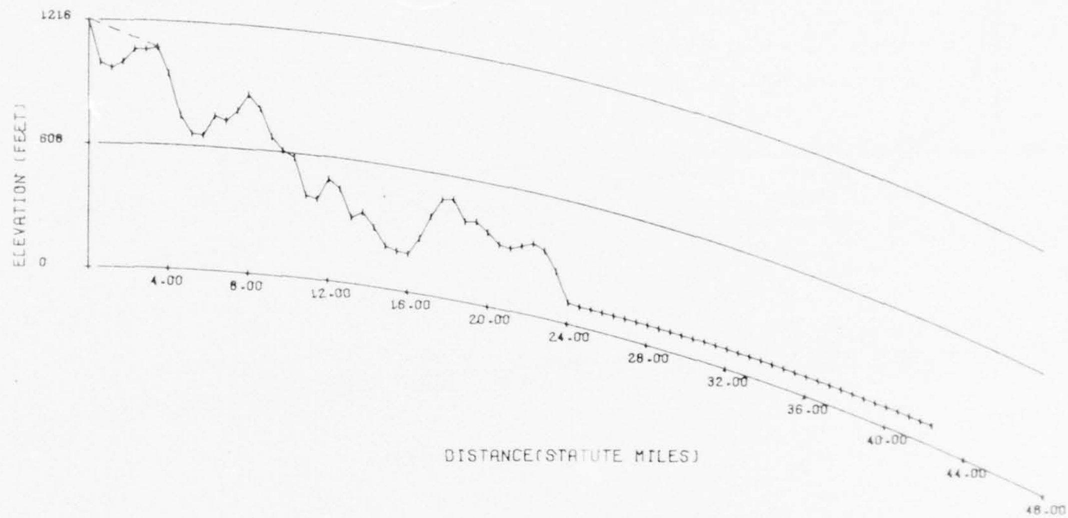
CULVERS GAP-BUDD LAKE
TERRAIN PROFILE - 4/3 EARTH

TX LAT= 41-11-15 N TX LON=74-48-0 W RX LAT=40-53-42 N RX LON=74-45-3 W
TX ELEV= 1515.00 FT RX ELEV= 1066.80 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT



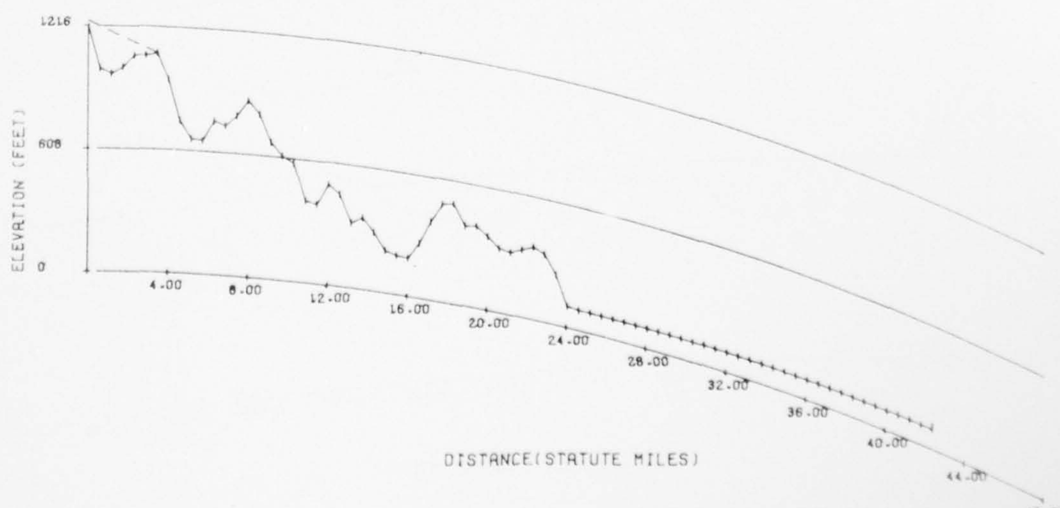
BUDD LAKE-JAMESBURG 1
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-53-42 N   TX LON:74-45-3 W   RX LAT:40-19-47 N   RX LON:74-26-13 W
TX ELEV= 1210.00 FT   RX ELEV= 100.00 FT
TX ANT HGT= 10.00 FT   RX ANT HGT= 10.00 FT



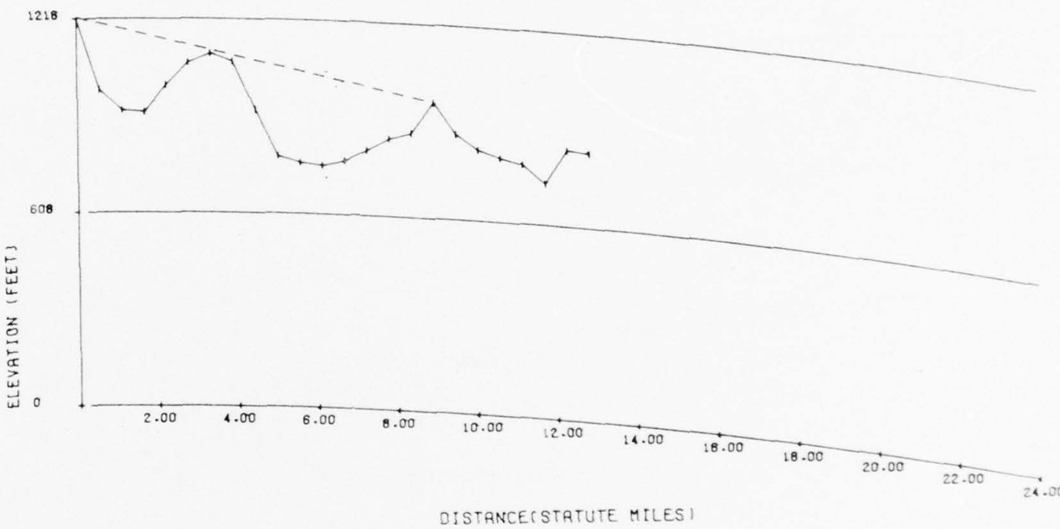
BUDD LAKE-JAMESBURG 1
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-53-42 N   TX LON:74-46-3 W   RX LAT:40-19-47 N   RX LON:74-28-13 W
TX ELEV= 1210.00 FT   RX ELEV= 100.00 FT
TX ANT HGT= 30.00 FT   RX ANT HGT= 30.00 FT



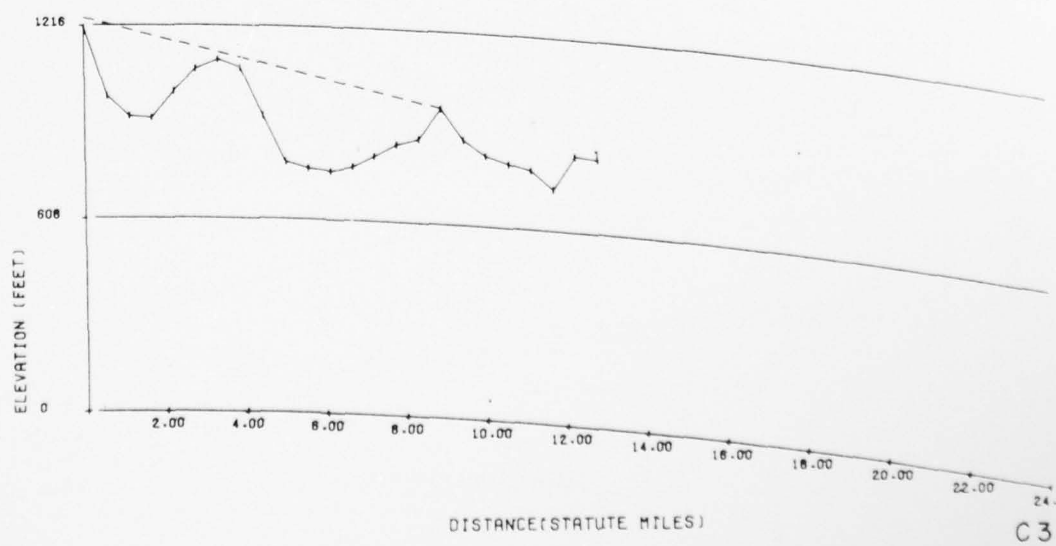
BUDD LAKE-GREYSTONE
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-53-42 N TX LON:74-46-3 W RX LAT:40-51-15 N RX LON:74-30-40 W
TX ELEV= 1210.00 FT RX ELEV= 843.32 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 10.00 FT



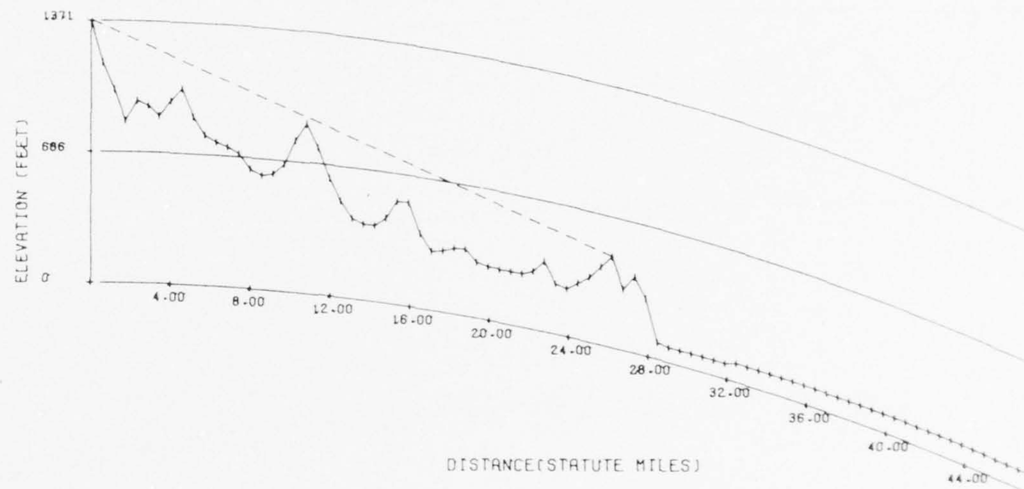
BUDD LAKE-GREYSTONE
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-53-42 N TX LON:74-46-3 W RX LAT:40-51-15 N RX LON:74-30-40 W
TX ELEV= 1210.00 FT RX ELEV= 843.32 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT



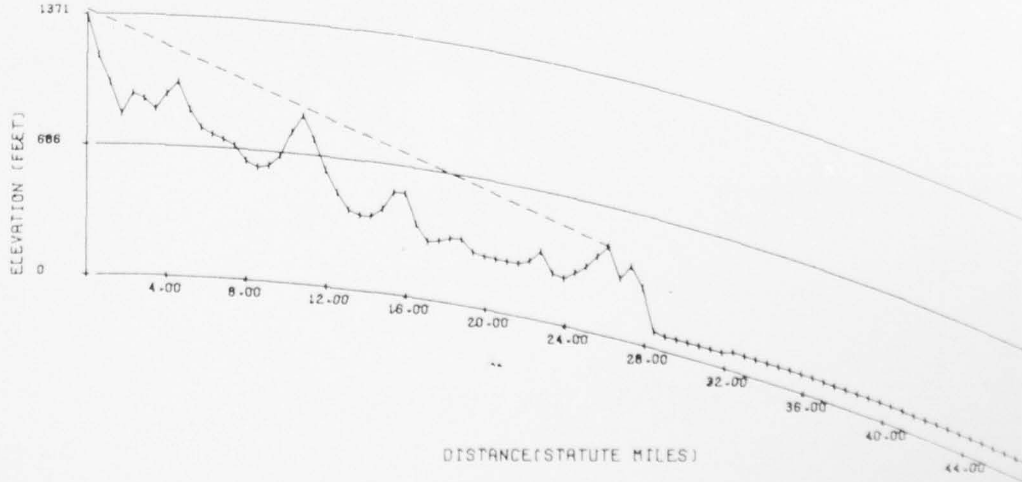
MILTON-JAMESBURG 1
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 41-0-32 N TX LON:74-32-28 W RX LAT:40-19-47 N RX LON:74-28-13 W
TX ELEV= 1365.00 FT RX ELEV= 100.00 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 30.00 FT



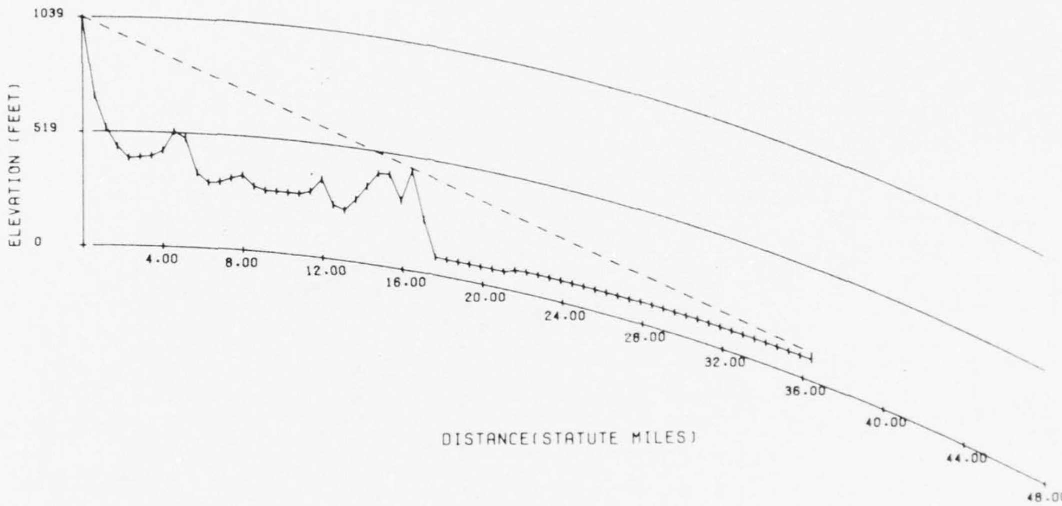
MILTON-JAMESBURG 1
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 41-0-32 N TX LON:74-32-28 W RX LAT:40-19-47 N RX LON:74-28-13 W
TX ELEV= 1365.00 FT RX ELEV= 100.00 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT



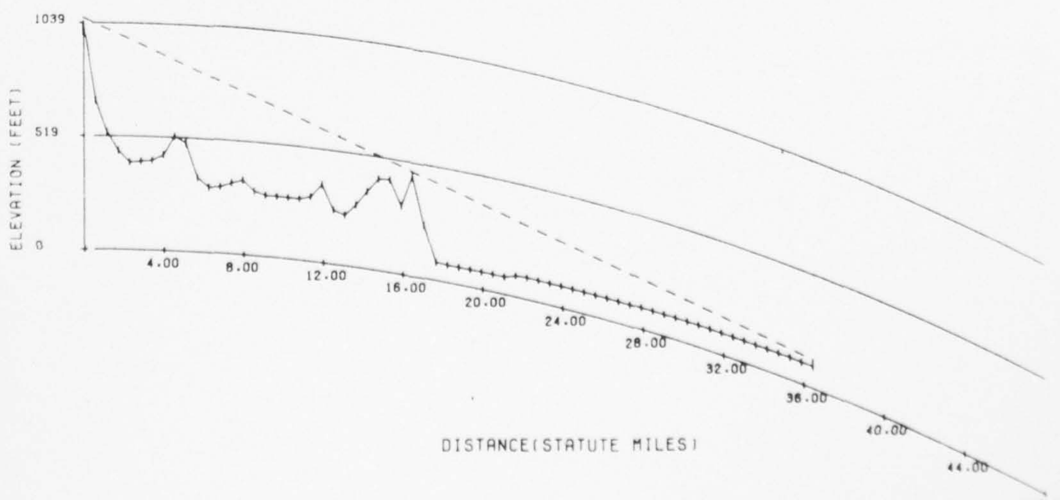
GREYSTONE-JAMESBURG 1
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-51-15 N TX LON:74-30-40 W RX LAT:40-19-47 N RX LON:74-26-13 W
TX ELEV= 1033.00 FT RX ELEV= 100.00 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 30.00 FT



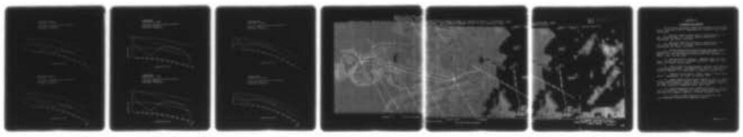
GREYSTONE-JAMESBURG 1
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-51-15 N TX LON:74-30-40 W RX LAT:40-19-47 N RX LON:74-26-13 W
TX ELEV= 1033.00 FT RX ELEV= 100.00 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT

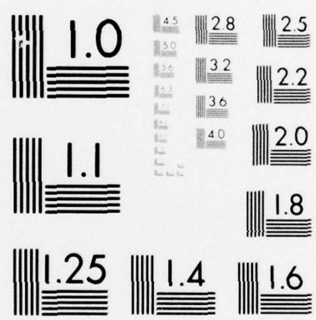


AD-A041 236 ARMY ELECTRONICS COMMAND FORT MONMOUTH N J F/G 17/2.1
DATA LINK VALIDATION PROGRAM.(U)
MAY 77 D J BLUE, R G WITHAM, S A BLEIER
UNCLASSIFIED ECOM-4500 NL

2 OF 2
AD A041236



END
DATE FILMED
7-77

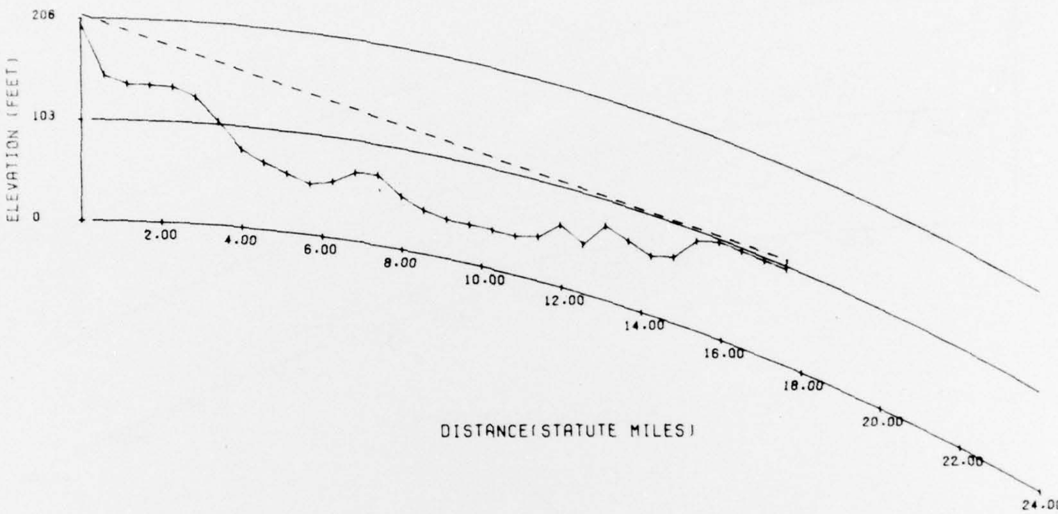


MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

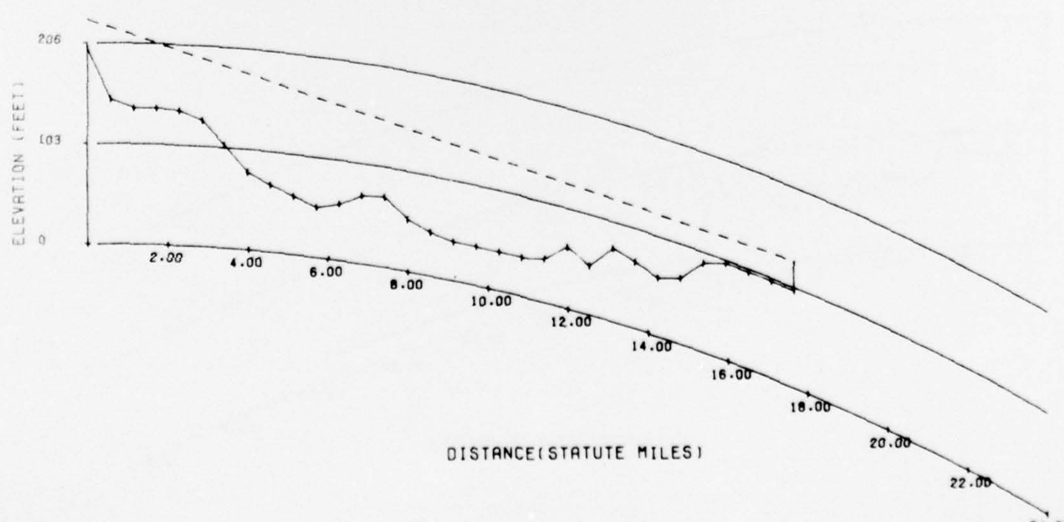
CEDAR BRIDGE-S.LAKEWOOD
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 39-49-49 N TX LON:74-20-28 W RX LAT:40-4-15 N RX LON:74-13-42 W
TX ELEV= 200.00 FT RX ELEV= 100.00 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 10.00 FT



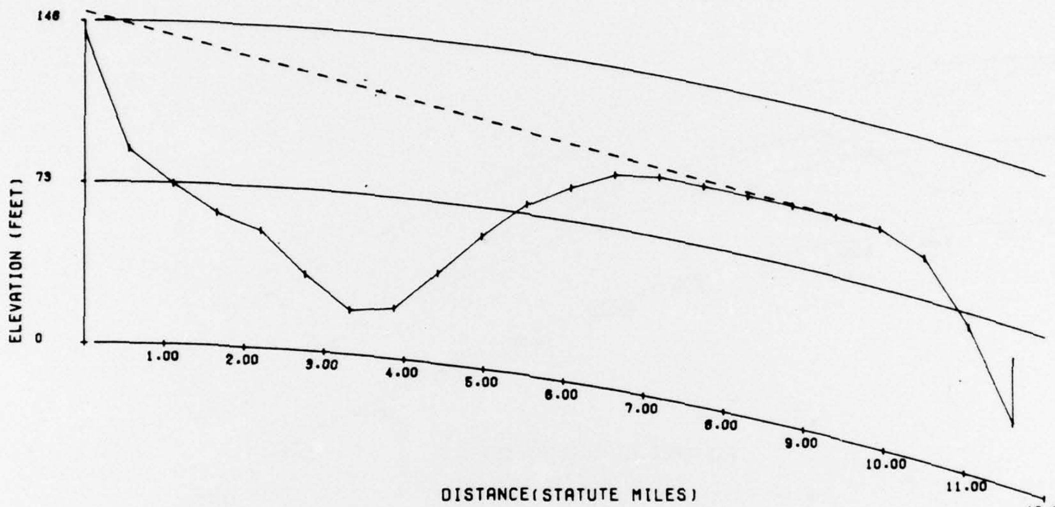
CEDAR BRIDGE-S.LAKEWOOD
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 39-43-49 N TX LON:74-20-28 W RX LAT:40-4-15 N RX LON:74-13-42 W
TX ELEV= 200.00 FT RX ELEV= 100.00 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT



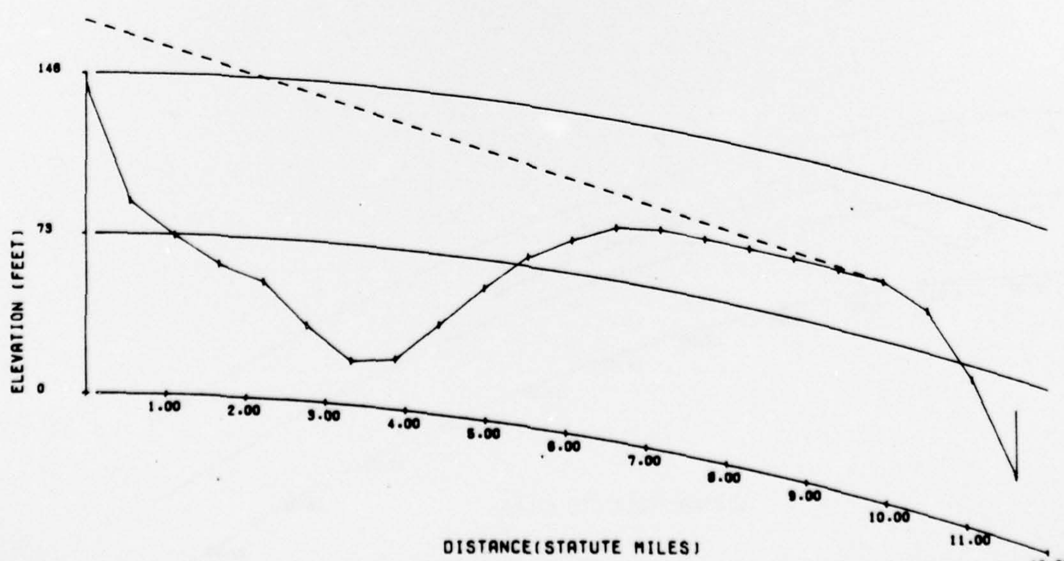
S.LAKEWOOD-EVANS
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-4-15 N TX LON:74-13-42 W RX LAT:40-10-58 N RX LON:74-3-52 W
TX ELEV= 140.00 FT RX ELEV= 29.33 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 30.00 FT



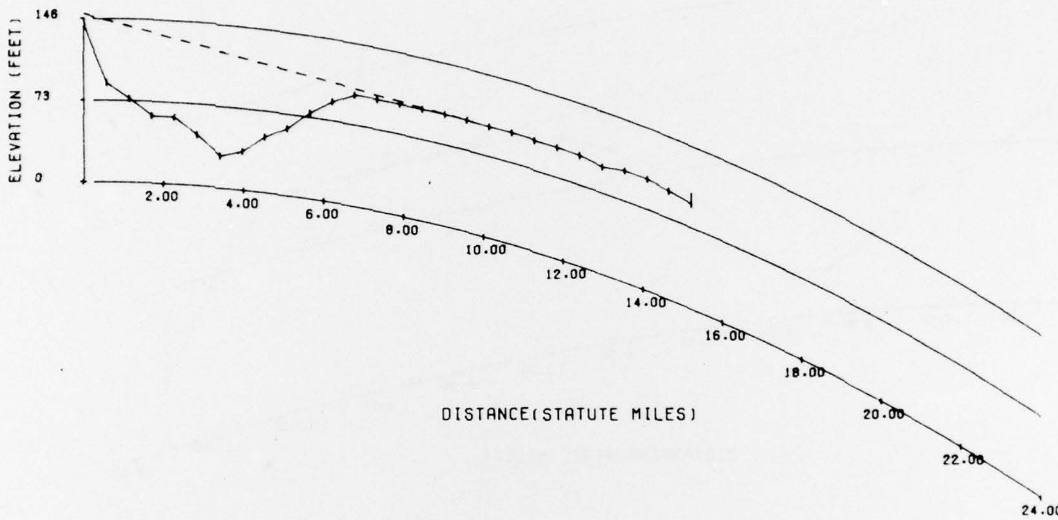
S.LAKEWOOD-EVANS
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-4-15 N TX LON:74-13-42 W RX LAT:40-10-58 N RX LON:74-3-52 W
TX ELEV= 140.00 FT RX ELEV= 29.33 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT



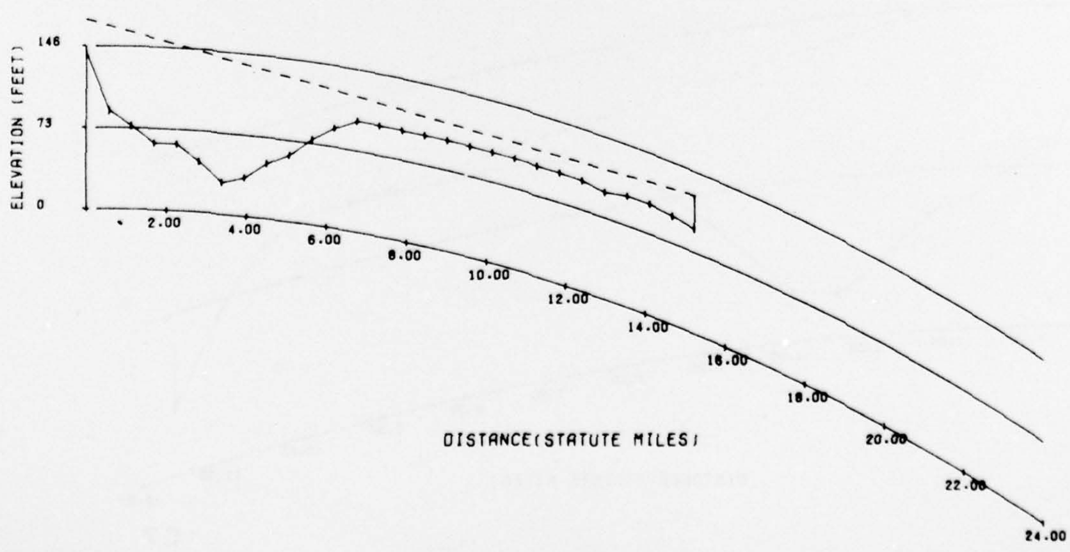
S.LAKEWOOD-OAKHURST
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-4-15 N TX LON:74-13-42 W RX LAT:40-14-21 N RX LON:74-2-32 W
TX ELEV= 140.00 FT RX ELEV= 94.40 FT
TX ANT HGT= 10.00 FT RX ANT HGT= 10.00 FT



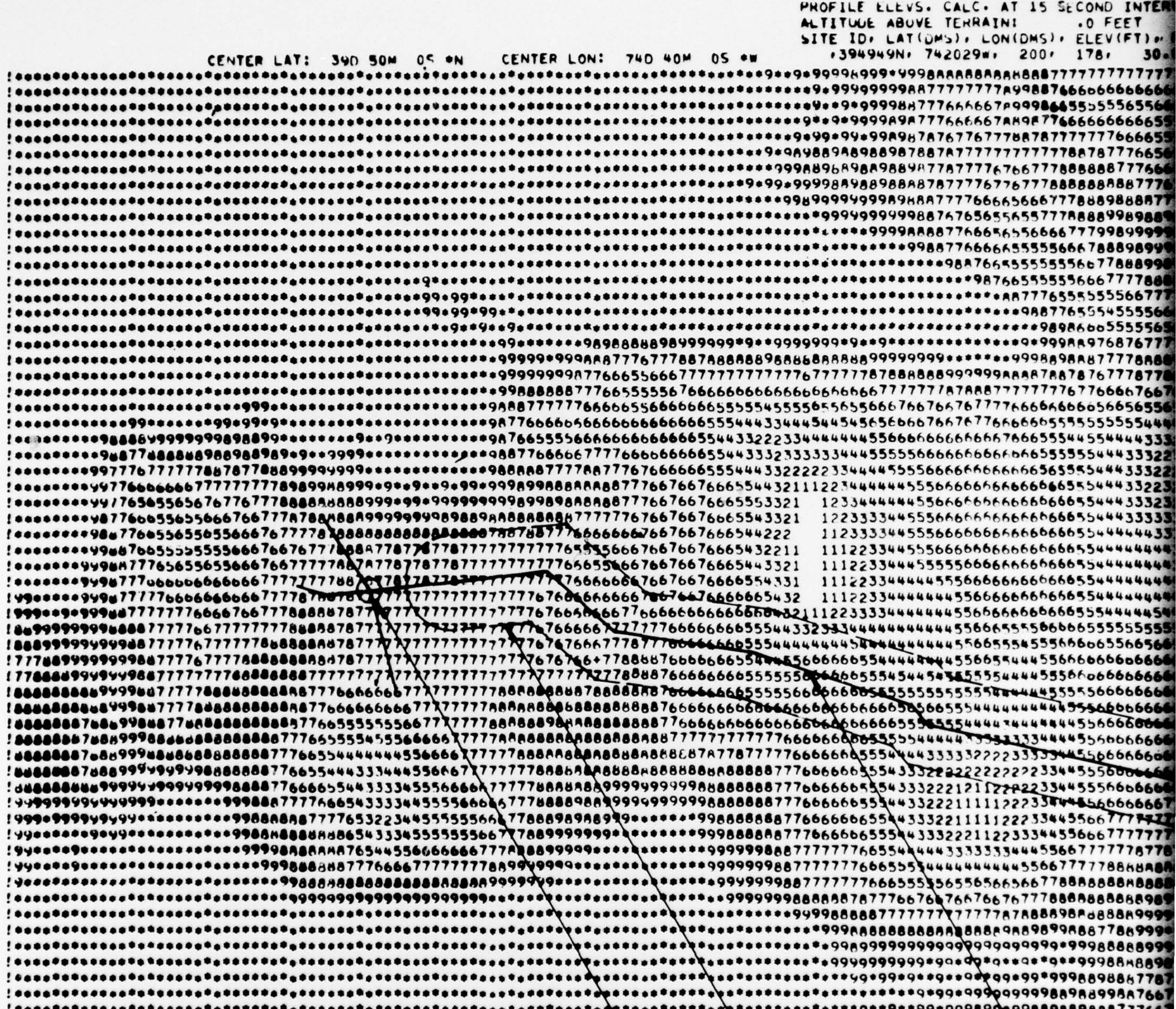
S.LAKEWOOD-OAKHURST
TERRAIN PROFILE - 4/3 EARTH

TX LAT: 40-4-15 N TX LON:74-13-42 W RX LAT:40-14-21 N RX LON:74-2-32 W
TX ELEV= 140.00 FT RX ELEV= 94.40 FT
TX ANT HGT= 30.00 FT RX ANT HGT= 30.00 FT



AREA:CEDAR NUMBER OF SITES: 1 CE
PROFILE ELEVS. CALC. AT 15 SECOND INTER
ALTITUDE ABOVE TERRAIN: .0 FEET
SITE ID, LAT(DMS), LON(DMS), ELEV(FT),
,394949N, 742029W, 200, 178, 30.

CENTER LAT: 39D 50M 0S *N CENTER LON: 74D 40M 0S *W



NUMBER OF SITES: 1 CENTER LAT: 39D 50M 05 *N CENTER LON: 74D 30M 05 *W REFRACTIVITY INDEX: 311.00
EVS. CALC. AT 15 SECOND INTERVALS BY 4 PT. METHOD AUX. ELEV. DATA: NO SCALE: 1 INCH= .99 ST. MI. (62500:1)
BOVE TERRAIN: .0 FEET DEGREE OF SHIELDING FACTOR: ONE UNIT= 10.0 FEET CLUTTER ANGLE: .00 DEG.
AT(DMS), LON(DMS), ELEV(FT), FILE ELEV(FT), ANT HT(FT)
N, 742029W, 200, 178, 30.0

GRID SHOWING DEGREE OF SHIELDING

2

REFRACTIVITY INDEX: 311.00
INCH= .99 ST. MI. (62500:1)
TTER ANGLE: .00 DEG.

CENTER LAT: 39D 50M 05 *N CENTER LON: 74D 20M 05 *W

R.F. DEGREE OF SHIELDING CHART
CEDAR BRIDGE TO APPLE PIE AND WARREN
GROVE AREAS

NO SCALE

C9

APPENDIX D

DOCUMENTS and REPORTS

The following documents, which are pertinent to low power relays, were felt to be of importance as a result of the literature search:

1. "Multiple EXRAY Systems Test at Camp Pendleton, CA (U)", SC-DR-72-0334, C.S. Sonnier, Sandia Laboratories, Albuquerque, NM 87115, June 1972.

2. "Multiple EXRAY System Tests at Camp LeJuene, NC (U)", SC-DR-72 0335, C.S. Sonnier, Sandia Laboratories, Albuquerque, NM 87115, June 1972.

3. "Sensor Communication Systems Path Loss Measurememts and Analysis", Fourth Quarterly Report, USAEPG-PR-777(4), F. Norris, U.S. Army Electronic Proving Ground, Fort Huachuca, AZ 85613, 1 May - 31 July 1973.

4. "Memo For Record, Subject: REMBASS Operating Ranges", Paul A. Major, EMC Office, Comm/ADP Laboratory, ECOM, Fort Monmouth, NJ 07703, 16 July 1973.

5. "Sensor Path Loss Measurements Analysis and Comparison with Propagation Models", OT Report 75-74, Anita G. Longley and George A. Hufford, U.S. Department of Commerce, October 1975.

6. "Repeater System Tests", 50P72, Naval Air Development Center, Warminster, Pa. 18974, 21 February 1975.

7. "Rapid Response Operational Support to the U.S. Marine Corps", ECAC-CR-76-019, James L. Small, IIT Research Institute for DOD Electromagnetic Compatibility Analysis Center, Annapolis, MD 21402, Contract F-19628-76-C-0017, April 1976.

8. "Audio Expendable Relay (EXRAY) Evaluation", Final Report, CC 29-0-01-6, CPT Robert L. Earl, Marine Corps Development and Education Command, Quantico, VA 22134, 26 April 1976.

9. "A Guide to ECAC Capabilities and Services, The Electromagnetic Compatibility Analysis Center."